# NATURE

*A Weekly Journal of Science*

Vol. 189, No. 4759 SATURDAY, JANUARY 14, 1961 2s. 6d.



Quicker than an analytical balance more accurate than a simple balance

**TORBAL**

**PRECISION BALANCES**

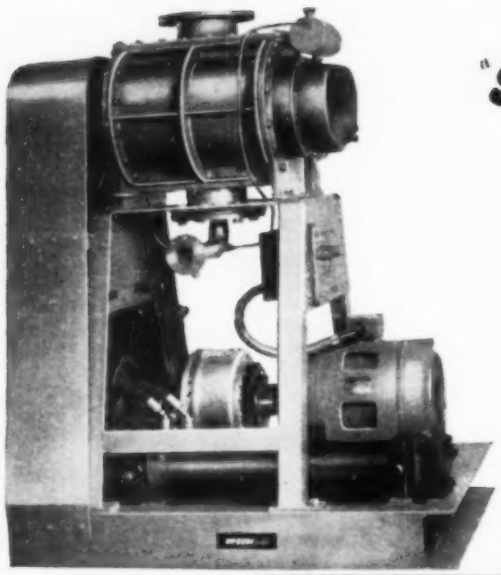
* NO KNIFE-EDGES * NO BEARINGS * NO SERVICING
* EASY DIAL OPERATION * ROBUST * EASILY PORTABLE

We are now demonstrating these remarkable American balances all over the country. They give you simple, rapid weighing with direct reading and being very robust can be moved about like no other balance, without loss of accuracy. The complete range includes Model DLT5, capacity 500 g., accuracy 50 mg., price £61. 0. 0; and DLT2, capacity 120 g., accuracy 5 mg., price £67.10.0. *Write now for full details and a demonstration on* your *bench.*

BT L complete laboratory service

BAIRD & TATLOCK (LONDON) LIMITED, CHADWELL HEATH, ESSEX, ENGLAND.
*Branches in London, Manchester, Glasgow.* *Agents in U.K. and all over the world.*

TA5/BT.88



"SPEEDIVAC"

# MECHANICAL BOOSTER PUMPS

*for high vacuum processing at high speeds in the range $10^{-1}$ to 10 torr*

| Pump Series Number | Normal Backing Pumps | Permanent Gas Ultimate Vacua Depending on Backing Pump (S) = Single Stage (C) = Combination (SG) = Single Stage With Full Gas Ballast | | | Theoretical Displacement per rev | Maximum Rev/min (Varies with pressure) | Peak Air Speed Depending on Backing Pump | | |
|---|---|---|---|---|---|---|---|---|---|
| | | torr (S) | torr (SG) | torr (C) | ft³ | | l/sec | ft³/min | m³/hr |
| 1R5 | | | | | 0·16 | 2000 | | | |
| | 1SC450 | $<5\times10^{-4}$ | $<2\times10^{-4}$ | $<10^{-4}$ | | | 85 | 180 | 305 |
| | 1SC900 | | | | | | 105 | 220 | 375 |
| 1R35 | | | | | 1·15 | 2000 | | | |
| | 1SC3000 | | | | | | 611 | 1300 | 2210 |
| | 2×1SC3000 | $<5\times10^{-4}$ | $<2\times10^{-3}$ | $<10^{-3}$ | | | 813 | 1730 | 2941 |
| | 1SC3000* | | | | | | 660 | 1400 | 2380 |
| | 2×1SC3000* | | | | | | 850 | 1800 | 3050 |

"Speedivac" mechanical boosters are equipped with fluid couplings in the drive from motor to pump. These devices vary the rotational speed of the pump so that the booster can be used for the whole roughing part of the cycle from atmospheric pressure downwards, thus avoiding the complication of by-pass lines, valves and switches.

Roots type mechanical boosters have high pumping speeds in the $10^{-1}$ to 10 torr pressure region and consequently are widely used for industrial applications such as vacuum metallurgy, impregnation and drying.

EDWARDS HIGH VACUUM LTD | MANOR ROYAL | CRAWLEY Crawley 1500 | SUSSEX | ENGLAND

CASELLA LONDON

# CASCADE IMPACTOR

**SAMPLES LIQUID AND SOLID PARTICLES UP TO 200μ**

The Casella Cascade Impactor, now redesigned, is in many ways complementary to the Thermal Precipitator, the important difference being that it will also sample the larger fractions of solid particles contained in dust clouds, and in addition liquid particles.

It will collect particles within the range 0.5μ to 50μ with an efficiency of 100%, and will also give valuable information about sizes up to 200μ.

*Write for leaflet No. 900/N*

C. F. CASELLA & CO., LTD. (Dept. N),
Regent House, Fitzroy Square, London, W.1 EUSton 3944/5/6/7

*Members of the Scientific Instrument Manufacturers' Association of Great Britain and the British Scientific Instrument Research Association.*

# The most efficient pump of its size

## 180 g.p.h. at 14′ head

**The "DAG" Mark 1 submersible pump. A very popular piece of equipment for laboratory work. It has a performance far in advance of any pump of its kind and size—from 500 g.p.h. at 4 ft. head to 180 g.p.h. at 14 ft. head. And this pump is only 15 in. overall length, weighs only 6 lbs., and is powered by only a 1/25 h.p. motor. All submersible parts are in best quality stainless steel. It is sturdily made to give a long working life at low initial cost. Full details of "DAG" pumps sent on request.**

**THERE IS A RANGE OF FOUR MODELS**

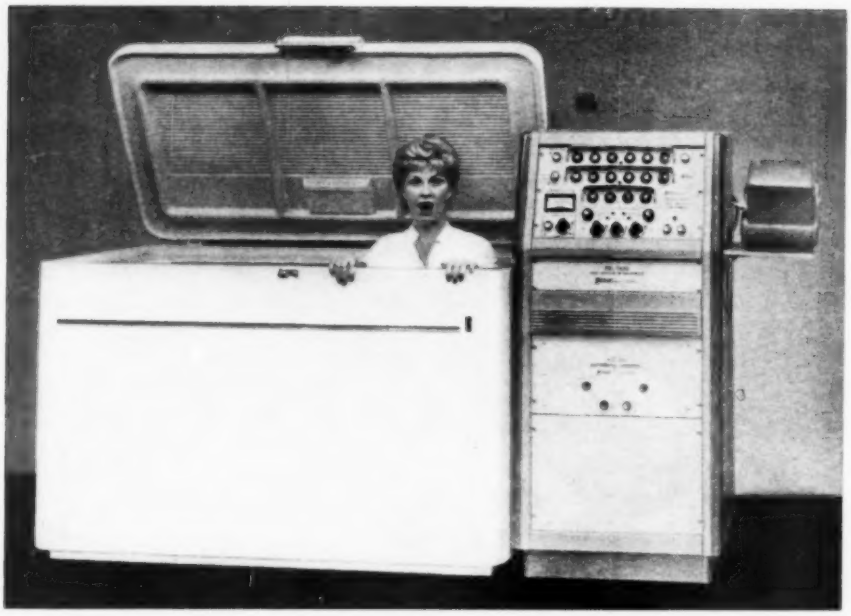
DAG

Reg. Trade Mark.

**D. A. GUNN (ENGINEERING) LTD**

**PARK ROAD NORTH, ACTON, LONDON W.3**

TEL. ACORN 4841-4



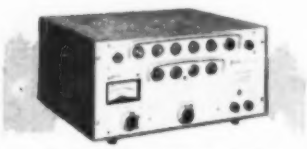
# It's What's Inside That Counts!

If you are counting radioactive isotopes . . .

tritium, carbon 14, iodine-131, iron-59 or any other alpha, beta or gamma tracer isotope . . .

you should know about the latest transistorized instruments designed and manufactured by Packard.

*Auto-Gamma System*



*Series 250A Automatic Scaler*

Whether or not you are planning to purchase new equipment, you will be interested in our latest bulletins which show "what's inside" these instruments that make them count so well . . . so reliably.

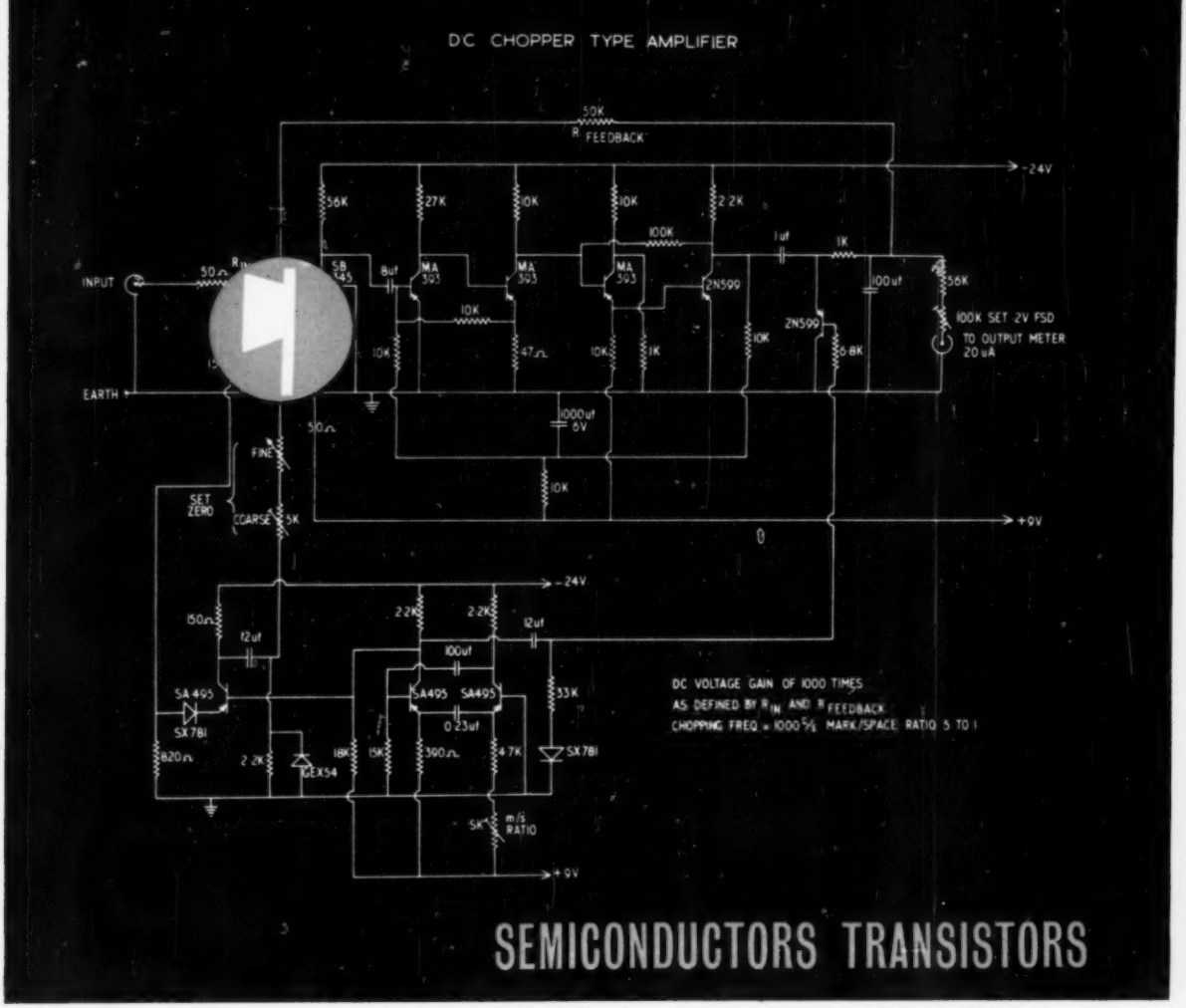
*Write or telephone requesting new instrument bulletins.*

TRI-CARB LIQUID SCINTILLATION SPECTROMETERS • AUTO-GAMMA SPECTROMETER SYSTEMS
FLOW DETECTORS • SCALERS • RATEMETERS

Packard Instrument Company, Inc.

BOX 428P • LA GRANGE, ILLINOIS • Phone HUnter 5-6330

CHICAGO • ATLANTA • BOSTON • LOS ANGELES • NEW YORK • PHILADELPHIA • PITTSBURGH
SAN FRANCISCO • WASHINGTON, D. C. • ALBUQUERQUE, N. M. • ZURICH • PARIS




# SEMICONDUCTORS TRANSISTORS

## FOR CHOPPER APPLICATIONS

Semiconductors' new Silicon Chopper Transistors are worth knowing about. The exclusive Semiconductors Limited Silicon Surface-Alloy process permits independent control of resistivity, base width and electrode diameter allowing transistors to be made specifically for chopper applications.

For the first time in the United Kingdom transistors are in production with these key performance features:—

Offset voltage guaranteed to be below 2 millivolts or 5 millivolts according to type.
Very low leakage currents.
Low hole-storage factor.
Low collector capacitance.
Minimum $f_T$ of 10 Mc s — minimising transient problems and permitting wide band widths.

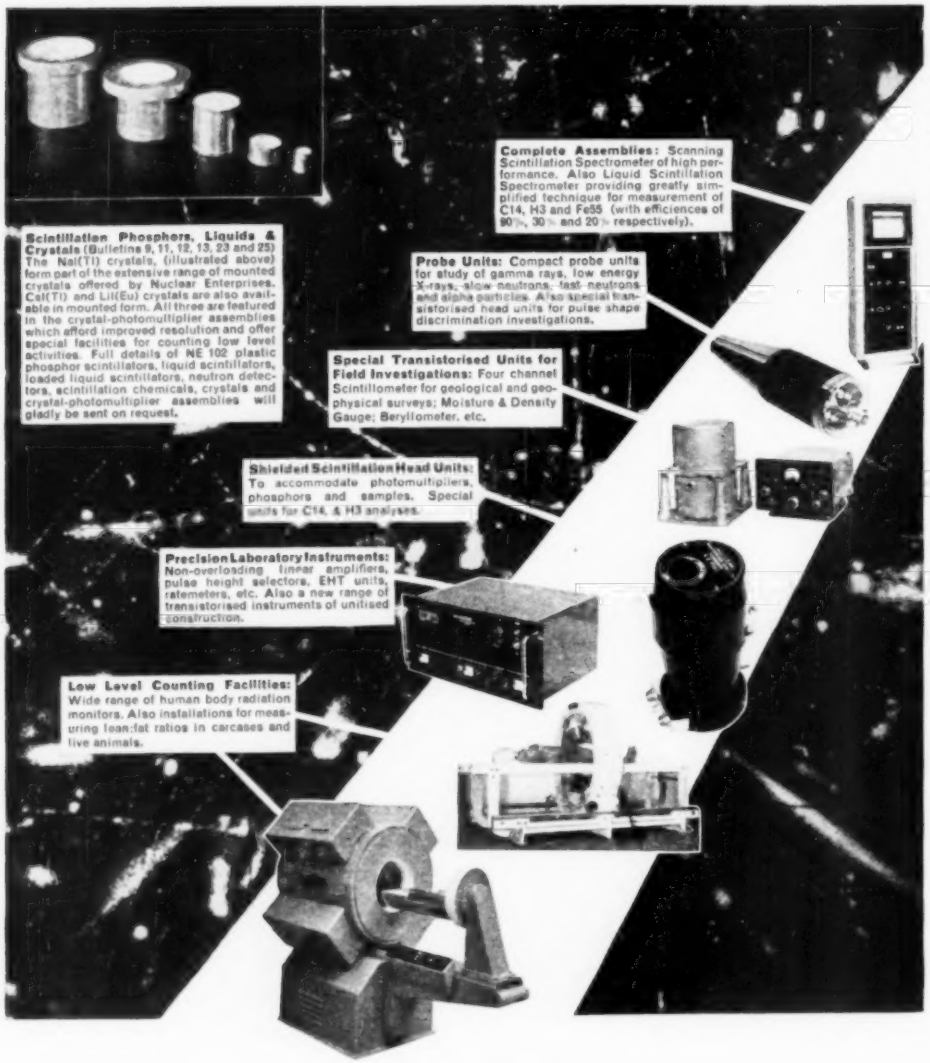
Write for Data Sheets to:

Semiconductors Limited

Cheney Manor · Swindon · Wiltshire Tel: Swindon 6421

ONE OF THE **Plessey** GROUP OF COMPANIES

# SCINTILLATION


Complete Assemblies: Scanning Scintillation Spectrometer of high performance. Also Liquid Scintillation Spectrometer providing greatly simplified technique for measurement of C14, H3 and Fe55 (with efficiences of 90%, 30% and 20% respectively).
Scintillation Phosphors, Liquids & Crystals (Bulletins 9, 11, 12, 13, 23 and 25) The NaI(Tl) crystals, (illustrated above) form part of the extensive range of mounted crystals offered by Nuclear Enterprises. CsI(Tl) and LiI(Eu) crystals are also available in mounted form. All three are featured in the crystal-photomultiplier assemblies which afford improved resolution and offer special facilities for counting low level activities. Full details of NE 102 plastic phosphor scintillators, liquid scintillators, loaded liquid scintillators, neutron detectors, scintillation chemicals, crystals and crystal-photomultiplier assemblies will gladly be sent on request.
Probe Units: Compact probe units for study of gamma rays, low energy X-rays, slow neutrons, fast neutrons and alpha particles. Also special transistorised head units for pulse shape discrimination investigations.
Special Transistorised Units for Field Investigations: Four channel Scintillometer for geological and geophysical surveys; Moisture & Density Gauge; Beryllometer, etc.
Shielded Scintillation Head Units: To accommodate photomultipliers, phosphors and samples. Special units for C14 & H3 analyses.
Precision Laboratory Instruments: Non-overloading linear amplifiers, pulse height selectors, EHT units, ratemeters, etc. Also a new range of transistorised instruments of unitised construction.
Low Level Counting Facilities: Wide range of human body radiation monitors. Also installations for measuring lean:fat ratios in carcases and live animals.

## NUCLEONIC INSTRUMENTS

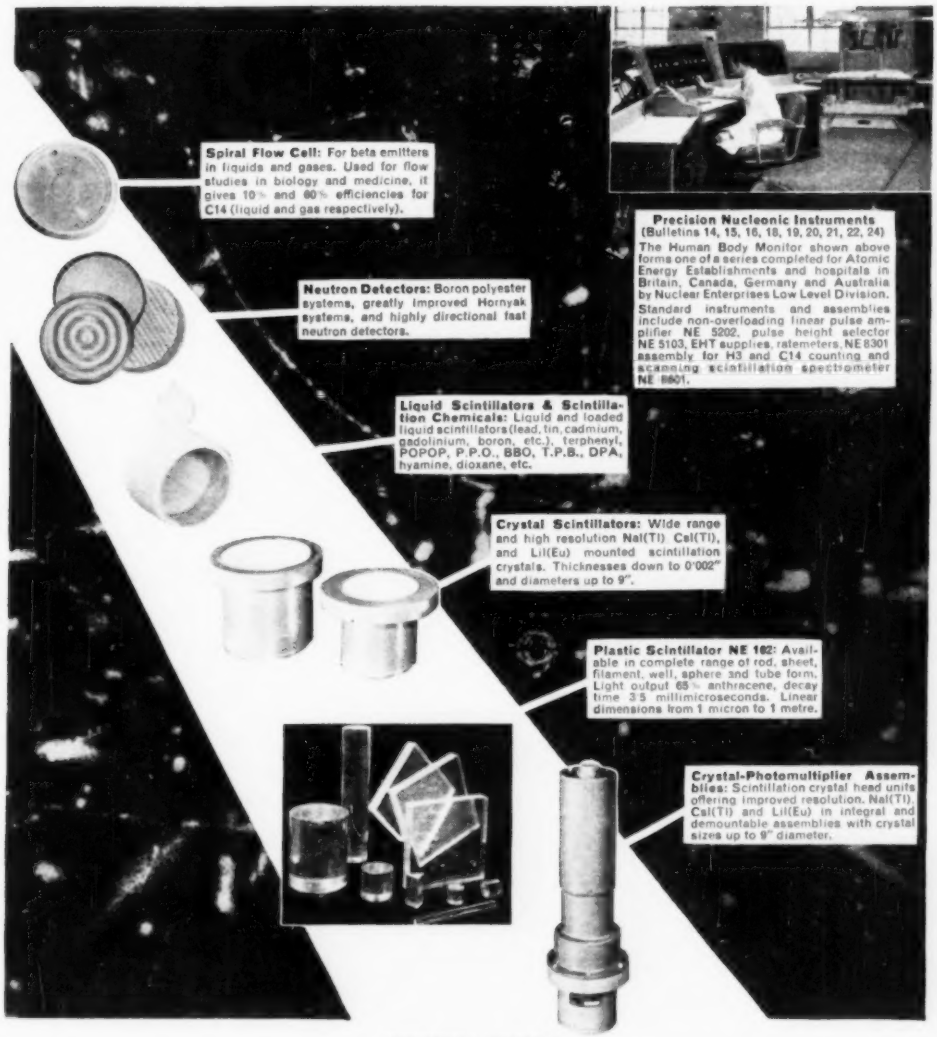
Nuclear Enterprises (G.B.) Ltd. offers a complete range of precision nucleonic instruments and a special design and development service to meet individual customer requirements.

**NEW:** NE 5550 and NE 5560 series probe units employing pulse shape discrimination techniques for detecting neutrons in a high gamma background.

For full details write for Technical Bulletins and Catalogue to Sales Division, Nuclear Enterprises (G.B.) Ltd., Sighthill, Edinburgh, 11.

7788

# COUNTING


Spiral Flow Cell: For beta emitters in liquids and gases. Used for flow studies in biology and medicine, it gives 10% and 60% efficiencies for C14 (liquid and gas respectively).
Neutron Detectors: Boron polyester systems, greatly improved Hornyak systems, and highly directional fast neutron detectors.
Liquid Scintillators & Scintillation Chemicals: Liquid and loaded liquid scintillators (lead, tin, cadmium, gadolinium, boron, etc.), terphenyl, POPOP, P.P.O., BBO, T.P.B., DPA, hyamine, dioxane, etc.
Crystal Scintillators: Wide range and high resolution NaI(Tl) CsI(Tl), and LiI(Eu) mounted scintillation crystals. Thicknesses down to 0·002" and diameters up to 9".
Plastic Scintillator NE 102: Available in complete range of rod, sheet, filament, well, sphere and tube form. Light output 65% anthracene, decay time 3·5 millimicroseconds. Linear dimensions from 1 micron to 1 metre.
Crystal-Photomultiplier Assemblies: Scintillation crystal head units offering improved resolution. NaI(Tl), CsI(Tl) and LiI(Eu) in integral and demountable assemblies with crystal sizes up to 9" diameter.
Precision Nucleonic Instruments (Bulletins 14, 15, 16, 18, 19, 20, 21, 22, 24)
The Human Body Monitor shown above forms one of a series completed for Atomic Energy Establishments and hospitals in Britain, Canada, Germany and Australia by Nuclear Enterprises Low Level Division.
Standard instruments and assemblies include non-overloading linear pulse amplifier NE 5202, pulse height selector NE 5103, EHT supplies, ratemeters, NE 8301 assembly for H3 and C14 counting and scanning scintillation spectrometer NE 8801.

## SCINTILLATORS

The unique scintillation service afforded by Nuclear Enterprises (G.B.) Ltd. includes the highly efficient NE 102 plastic scintillator, liquid scintillators, neutron detectors, scintillation chemicals and an extensive range of crystals and crystal-photomultiplier assemblies.

**NEW:** NE 150 plastic phosphor for pulse shape discrimination techniques and NE 160, a special high temperature plastic scintillator.

**Nuclear Enterprises (G.B.) Ltd**

**SIGHTHILL, EDINBURGH, SCOTLAND**

**Tel: CRAiglockhart 5262**

Associate Company:
Nuclear Enterprises Ltd., 550 Berry Street, Winnipeg 12, Canada

DERRITRON Electronics GROUP

BEME TELECOMMUNICATIONS LTD . BEULAH ELECTRONICS LTD
CHAPMAN ULTRASONICS LTD . DORAN INSTRUMENT CO. LTD
ELECTRONIC VIBRATORS LTD . L.S.B. COMPONENTS LTD . RESLOSOUND LTD.

# T.V. MICROSCOPY IS NOW WITHIN THE REACH OF ALL LABORATORIES

Beulah Research have now produced the D.800 camera which enables the smallest of closed circuit TV microscopy. The Beulah D.800 is extremely compact and light. It measures only 12 in. × 7 in. × 6 in., and weighs approximately 14 lbs. It can be used with any standard TV Receiver ; and it is so sensitive that ordinary room lighting is sufficient to obtain excellent pictures. It will feed as many as 20 TV receivers and cover distances up to 4,000 feet so it is equally useful to the large laboratory or hospital as it is so small. For special applications, the camera can be supplied with ultra-violet or infra-red sensitive tubes. We will gladly arrange a demonstration for you.

**Price: 225 gns**

*Write for the free illustrated brochure which gives full details and specifications.*

BEULAH ELECTRONICS

**You can see demonstrations of the BEULAH D.800 on DORAN INSTRUMENT STAND No. 110 at the Physical Society Exhibition**

## BEULAH ELECTRONICS LTD

sales enquiries for all companies · 24 UPPER BROOK ST · MAYFAIR · LONDON · W1 · PHONE HYDE PARK 2291

Da1416N

# transistor stabilised
# mains operation

See us at Stand 106
at the
Physical Society Exhibition,
January 16–20

## Spectrophotometer power supply
### 115 D

The unit employs a conventional series stabilizer system, a compensating double zener reference being used to provide a high degree of stabilisation. Particular care has been taken in the design to minimise the temperature rise of the sampling and control components due to the heat dissipation in the series regulators. The use of the latest type power transistors together with cast alloy heat sinks permit the unit to operate in high ambient temperatures under adverse mains input conditions. First quality components are employed throughout making the unit suitable for pan-climatic use.

*For further information please write or telephone*

**Labgear Limited**

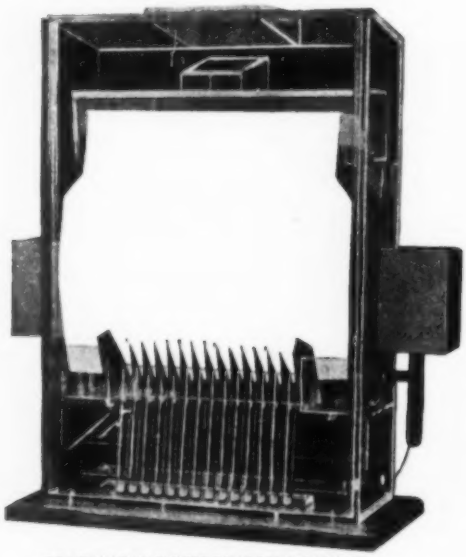
**WILLOW PLACE, CAMBRIDGE. Cambridge 88022**

LABGEAR

# ELECTROPHORESIS

## ADAPTORS & UNITS

*For Starch Gel, Cellulose Acetate & Continuous Electrophoresis*



CONTINUOUS ELECTROPHORESIS CABINET

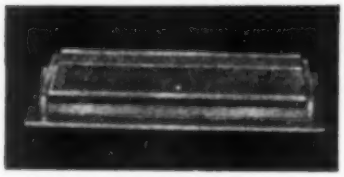
The increasing adoption of these techniques has led to a growing demand for suitable equipment with which to supplement the already well-known "EEL" Electrophoresis Apparatus. Users of the standard "EEL" apparatus will be pleased to learn of the adaptors now available and which have provided successful results in extended tests. These low priced attachments offer the clearer separations obtainable with these new methods at a fraction of the normal cost and at the same time enable the user to employ existing equipment.

### CONTINUOUS ELECTROPHORESIS

The apparatus for this purpose is the "EEL" cabinet illustrated which houses the reservoirs for the buffer solution and samples, the electrophoretic curtain, capillary glass tubing, test tubes, electrodes, etc. It is closed with a sliding panel and a plastic hood is provided.

### STARCH GEL

The adaptor for these determinations consists of a Perspex tray (15×5 cm.), tray cover and three spacers. The tray is fitted with a false bottom on to which the gel may be poured to attain a depth of 6 mm. It may afterwards be cut into four layers each 1.5 mm. thick by progressively inserting the spacers and slicing with the "EEL" Gel Slicer (not illustrated).

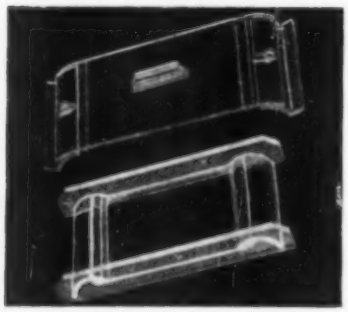


STARCH GEL TRAY

CELLULOSE ACETATE TRAY

### CELLULOSE ACETATE

The adaptors for the electrophoretic bath take the form of a tray (14.5×7.5 cm.) with supports on which the acetate strips may be mounted. The tray is closed with a lid which has an ingenious tensioning device ensuring each strip being drawn taut after it has been placed on the paper wicks. The strips may be scanned on the standard "EEL" Scanner by using the "EEL" Scanner Adaptor (not illustrated) which is interchangeable with that on the standard model.



### THE POWER UNIT

This is a constant current unit with a maximum output of 50 m.a. 600 volts, with full wave rectification, for use with Starch Gel and Continuous Electrophoresis. For Cellulose Acetate the standard "EEL" Power Unit may be employed.

*Fuller details are available from the manufacturers*

**EVANS ELECTROSELENIUM LTD.**

**Sales Division 66, St. Andrew's Works, Halstead, Essex.**
**Phone Halstead 2461**

SALES AND SERVICING AGENTS THROUGHOUT THE WORLD

# NATURE

No. 4759 SATURDAY, JANUARY 14, 1961 Vol. 189

## CONTENTS

| | Page |
|---|---|
| Nigeria's Investment in Education | 85 |
| Cotton in India. By Prof. S. C. Harland, F.R.S. | 86 |
| Mineral Processing. By Dr. A. R. Burkin | 87 |
| Electromagnetism and Relativity. By Prof. J. Hamilton | 87 |
| Essentials of Logistics. By F. I. G. Rawlins, C.B.E. | 88 |
| Catalysis. By Dr. E. B. Maxted | 88 |
| Evolution. By Dr. G. S. Carter | 89 |
| Zoological Literature for 1957. By Dr. Edward Hindle, F.R.S. | 89 |
| Radioactive Fall-out in Israel resulting from the Nuclear Tests in the Sahara Desert. By Y. Feige, E. Shalmon, J. Vardi, J. R. Gat (Gutmann) and Y. L. Tokatly | 90 |
| Post-Secondary and Higher Education in Nigeria. By Dr. C. T. Mortimer | 95 |
| Vertebrate Locomotion. By Prof. John E. Harris | 97 |
| Obituaries: | |
| Prof. W. J. Duncan, C.B.E., F.R.S. By Ernest F. Relf, C.B.E., F.R.S. | 98 |
| Prof. J. G. Andersson. By Dr. Erik Åhman | 99 |
| Dr. Louis Clarke. By M. C. Burkitt | 99 |
| News and Views | 100 |
| New Buildings at the Fire Research Station. By D. I. Lawson | 105 |
| Future of the General Degree in British Universities. By Prof. F. C. Frank, O.B.E., F.R.S. | 106 |
| The University Grants Committee | 107 |
| Wind Tunnels and Flow Visualization. By C. Scruton | 108 |
| Primary and Initial Effects of Ionizing Radiations. By Dr. Peter Alexander | 110 |
| Coke Research | 112 |
| Solid State Physics at Melbourne | 113 |
| Scientific Research in Belgium | 113 |
| Myocardial Tissue Changes associated with Rigor Mortis | 114 |
| Bower-Birds | 114 |
| Radar Echoes from the Aurora at 1,300 mc./s. By Dr. E. Eastwood, G. A. Isted and J. D. Bell | 115 |
| A Versatile Method for Short-term Spectrum Analysis in 'Real-Time'. By J. S. Gill | 117 |
| Nucleic Acids in Deuterium Oxide Solution. By Y. Kyogoku, M. Tsuboi, T. Shimanouchi and I. Watanabe | 120 |
| Gradient of Cholinesterase Activity and of Choline Acetylase Activity in Nerve Fibres. By Dr. L. Lubińska, S. Niemierko and B. Oberfeld; Dr. Catherine O. Hebb and Ann Silver | 122 |
| Glycerol in *Mycoplasma mycoides*. By A. W. Rodwell; P. Plackett | 125 |

(Continued overleaf)

• SIMPLICITY

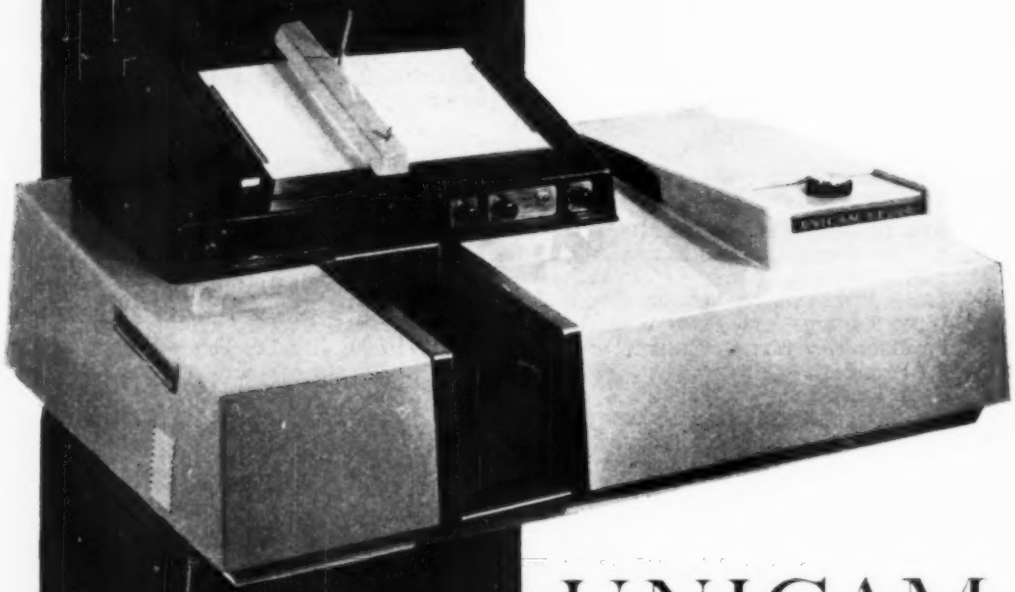
• RELIABILITY

• ECONOMY

The New SP 200
Infrared Spectrophotometer
will be demonstrated at the
PHYSICAL SOCIETY
EXHIBITION stand 107

Please write for tickets

The UNICAM SP.200 Infrared Spectrophotometer combines exceptional performance with many outstanding features rarely found in a low-cost instrument. The flat-bed recorder with linear wavenumber scale between 650 $cm^{-1}$ and 5000 $cm^{-1}$, the ball point pen, variable slit programme, temperature stabilised monochromator, monitoring panel, single control operation are all important features to the busy analytical chemist and are only available together in the SP.200. For full information on this outstanding instrument please write to Unicam Instruments Ltd.



SP 200 ECONOMY

UNICAM
INFRARED
SPECTROPHOTOMETER

UNICAM INSTRUMENTS LIMITED · ARBURY WORKS · CAMBRIDGE
U203

# LETTERS TO THE EDITORS


Page

ASTROPHYSICS

The Dust Cloud about the Earth.—Dr. Fred L. Whipple . . . . . 127

Ionospheric Disturbance at the Time of Cosmic Ray Increases.—C. Collins and D. H. Jelly . 128

RADIOPHYSICS

Irregular Fading of Satellite Transmissions.—Dr. W. C. Bain . . . . . 129

PHYSICS

Random Fluctuations in a Nuclear Fission Reactor.—L. G. Kemeny and Samaun . . 130

Time-dependent Tensile Strength of Solids.—I. H. Hall . . . . . 131

Composition Requirements for Glass Formation in Metallic and Ionic Systems.—Prof. M. H. Cohen and D. Turnbull . . . . . 131

Ultra-Violet Absorption Spectrum of Water.—R. M. Golding . . . . . 132

METALLURGY

Microhardness and Other Properties of Magnesium Compounds with the Calcium Fluoride Structure.—E. R. Petty . . . . . 132

ENGINEERING

Reactions on Metal Surfaces at High Temperatures.—F. T. Barcroft and J. R. Hayden . 133

CHEMISTRY

Use of Krypton for Surface Area Measurements.—Dr. John M. Thomas . . . . . 134

Reaction of Oxygen Atoms with Hydrogen.—M. A. A. Clyne and Dr. B. A. Thrush . . 135

Origin of Some Primary Coal Tar Components.—Dr. M. Vahrman . . . . . 136

Organic Halides as Electron Acceptors in Charge Transfer Compounds.—T. Bjorvatten, Prof. O. Hassel and Chr. Rømming . . . . 137

BIOCHEMISTRY

Enzymic Synthesis of 3-*O*-α-D-Glycopyranosyl D-Xylose.—Dr. S. A. Barker, Prof. M. Stacey, F.R.S., and D. B. E. Stroud . . . . . 138

Applicability of Hydroxocobalamin as a Long-acting Vitamin $B_{12}$.—Prof. G. B. J. Glass, H. R. Skeggs, Dr. D. H. Lee, Dr. E. L. Jones and W. W. Hardy . . . . . 138

Later Stages of Protein Synthesis and the Role of Phospholipids in the Process.—Dr. G. D. Hunter and G. N. Godson . . . . . 140

An Iron Requirement for a Dissimilatory Nitrate Reductase in *Neurospora crassa*.—G. C. Walker and Dr. D. J. D. Nicholas . . . . . 141

Synthesis of L-Methionyl-L-Glutamyl-L-Histidyl-L-Phenylalanyl-L-Arginyl-L-Tryptophyl-Glycine and its Melanocyte-stimulating and Corticotropin-releasing Activity.—Prof. Choh Hao Li, Eugen Schnabel, David Chung and Tung-bin Lo . . . . . 143

Biosynthesis of $^{14}$C-Sclareol and β-Sitosterol from 2-$^{14}$C-Mevalonic Acid.—Prof. Harold J. Nicholas 143

Utilization of the Stereoisomers of *Iso*leucine by *Lactobacillus arabinosus* 17–5.—Dr. Ichiro Chibata, Shigeki Yamada and Hiroshi Ito . 144

A Simple Paper Chromatographic Method for Determination of Amino-Acid Activation Profiles in Tissue Preparations.—Dr. Alexandra von der Decken . . . . . 145

PHYSIOLOGY

Anticomplementary Action of Aspirin.—Dr. C. J. van Oss, J. C. Friedmann and Dr. M. Fontaine 147

Page

Possible Sources of Tartronate Deficiency in Man.—Laurence G. Wesson . . . . . 147

A New Green-Leaf Growth-stimulating Factor, Phyllococosine, from Coconut Milk.—Dr. Susumu Kuraishi and Dr. F. Shigeo Okumura. . 148

Differential Sublimation Rates of Light and Tritium-labelled Water.—Dr. R. Moore and Dr. E. R. Buskirk . . . . . 149

RADIOBIOLOGY

Dose-Response Relationship in Radiation Carcinogenesis.—Dr. Niels Arley and Reidar Eker . . . . . 151

Action of Neurohypophyseal Hormones on the Sodium Fluxes of a Freshwater Teleost.—Dr. J. Maetz and M. Julien . . . . . 152

CYTOLOGY

Implication of Chromosome Structure and Replication on Hazard of Tritiated Thymidine and the Interpretation of Data on Cell Proliferation.—Eugene P. Cronkite, Samuel W. Greenhouse, Dr. George Brecher and Victor P. Bond . . . . . 153

Chromosome Anomaly in Two Cases of Cerebral Palsy, a Brother and a Sister.—Dr. J. Blumel, Y. Ohnuki and A. Awa . . . . . 154

BIOLOGY

Honeybee Communication when the Sun is Close to the Zenith.—Dr. D. A. T. New, F. R. Burrowes and A. J. Edgar . . . . . 155

Morphogenetic Effects of Lipoic Acid on Amphibian Embryos.—Prof. J. Brachet . . . . 156

Localization of the Cells of Origin of the Ventral Spino-Cerebellar Tract.—J. I. Hubbard and O. Oscarsson . . . . . 157

A Chitin Medium for Isolation, Growth and Maintenance of Actinomycetes.—Yamuna Lingappa and Prof. John L. Lockwood . . 158

Injury by Soaking of *Populus alba* Seeds.—Dr. L. Pólya . . . . . 159

High Polyploidy in a New Zealand *Poa*.—J. B. Hair and E. J. Beuzenberg . . . . . 160

BACTERIOLOGY

Absence of the Glucose Effect on the Frequency of Lysogenization in *Salmonella typhimurium*.—Patricia Hoffee, Roger Weinberg and Prof. Ellis Englesberg . . . . . 160

Isolation and Some Properties of the Phages of *B. cereus* NRRL 569.—Dr. J. Földes, Katalin Merétey and István Varga . . . . . 161

GENETICS

Diurnal Temperature Fluctuation and Genetic Variance in *Drosophila* Populations.—J. A. Beardmore . . . . . 162

FOREST PRODUCTS

A Method of obtaining Uniform Distribution of Wood Preservatives in Toxicity Test Blocks.—D. N. R. Smith and R. Cockcroft . . . 163

SOIL SCIENCE

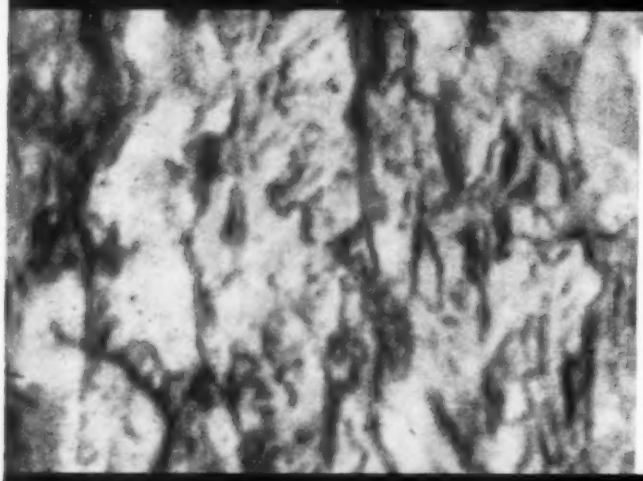
Soil Phosphate Solubility.—S. Larsen and M. N. Court . . . . . 164

Direct Methods of Estimation in the Spectrographic Analysis of Cobalt in Soil Concentrates.—Dr. A. B. Calder . . . . . 165

ARCHÆOLOGY

An Extinct Giant Pangolin and Associated Mammals from Niah Cave, Sarawak.—Tom Harrisson, D. A. Hooijer and Lord Medway . . 166

The microscope....



and the **Kodak** 0.250 plate

The 0.250 'Kodak' Rapid Ortho Metallographic Plate was designed specially for photomicrography. It has a medium-speed orthochromatic emulsion of variable contrast and high resolving power. Its highest sensitivity is in the region of maximum visual sensitivity, where most microscopes yield sharpest focus.

Details are given in 'Kodak' Data Sheet PL-11, free on request.

KODAK LIMITED,
INDUSTRIAL SALES DIVISION,
KODAK HOUSE,
KINGSWAY, LONDON, W.C.2.

## *Applied Mechanics for Engineers*

**J C GRASSIE DSc AMICE AMIStructE**

'There are few books published that deal with the vast subject of mechanics in such a concise way as this one . . . Many easy-to-follow examples are quoted, and useful exercises are set. (Step by step, the principles involved are set out, and it is thus possible to see a solution to any obscure problem.)'
*F. Smith, Engineering Material and Design*

'. . . deals with the elements of statics, kinematics, dynamics, stress and elasticity as covered in the first two years of an undergraduate course . . . The presentation of the subjects, the paper, the printing and the diagrams are all excellent. . . . A sound introduction to the subject.' *Engineer* 45s

## *Mathematical Toolkit for Engineers Second Edition 1960*

**H A WEBB MA and D G ASHWELL MA PhD AMICE**

'Those who have seen and used the first edition of this book will not be surprised that it has gone into a second edition so soon. (It enables the practising engineer readily to brighten up his mathematics . . . without having to search out his requirements in the pages of a large formal text-book . . .) It contains just that kind of collected, concise presentation that serves so well as a basis for practice and revision. To the contents of the first edition there have been added four extra topics—complex numbers, Macaulay's method, Laplace transform and theory of errors.' *Technology* 15s

**LONGMANS GREEN & CO LTD · 6 & 7 CLIFFORD STREET · LONDON W1**

# NIGERIA'S INVESTMENT IN EDUCATION

THE proposals of the Commission on Post-School Certificate and Higher Education in Nigeria, reviewed on page 95 of this issue, are indeed massive, expensive and unconventional. To fulfil its recommendations 600 secondary schools, 6 technical institutes, 8 teacher-training colleges and 3 universities will have to be built and staffed during the next ten years. The programme will require about 4,000 graduate teachers on short-term contracts and 1,000 university teachers. The capital cost of the universities alone will approach £20 million, and a realistic estimate of the total recurrent costs would be £50 million over the next decade. To provide sufficient graduate teachers will entail an expenditure of about £20 million over the ten-year period. The Commission makes no estimate of the capital cost of the schools, colleges and institutes; but it seems unlikely that the overall cost of implementing the proposals will be less than £150 million between now and 1970. Aid will have to be provided on an international scale.

The Commission has obviously been placed in a dilemma. A programme of this magnitude is necessary to enable Nigeria, a country with potential, rather than present, wealth, to expand economically and take its right place among the nations. But the proposals come at a time when there is considerable expansion in secondary schools and universities throughout the Commonwealth. The recruitment of sufficient teachers to 'prime the pump' of this educational programme is in itself a major project. To make it succeed, there will have to be considerable co-operation between Nigeria, Britain and the United States of America. The secondment of both school and university teachers will have to be encouraged from the English-speaking countries. Nigeria, on her part, must be willing to show a spirit of welcome to the large numbers of expatriates; to appreciate that decisions in educational matters must be independent of the changing winds of politics; and be eager to accept the advice of experts on the many problems which will arise.

In the last resort, the universities are the backbone of the country's educational system. It is important, therefore, to examine critically the Commission's recommendations as to how these institutions should be developed, governed and financed. It is proposed that there should be one large university in each of the three Regions, and that they should be financed largely from Federal funds. It is also suggested that the regional branches of the Nigerian College of Arts, Science and Technology, which are Ibadan in the west, Enugu in the east, and Zaria in the north, should become centres of university education.

While the Ibadan branch could be absorbed easily by the adjacent University College, it would be more difficult for the Enugu branch of the Nigerian College to form as close links with the University of Nigeria, at Nsukka, some 40 miles away. In the Northern Region, the problem of geographical separation of the different parts of a single university is more acute. Zaria, which already has an engineering faculty as a basis for university development, is 75 miles from the Ahmadu Bello College of Arabic Studies at Kano, and is 150 miles from Vom, where considerable development of the Veterinary Research Institute is envisaged. From this aspect alone, it may be necessary for the separate units to have much greater independence than would be possible in a single university. This might also help to solve another difficulty of which the Commission has taken insufficient cognizance.

In Nigeria to-day there are strong feelings of regional loyalty. These were a large part of the driving force which has already led to a university being established at Nsukka, to the development of the College of Arabic Studies at Kano, and also to the intention of the Western Region Government to found a new university. These institutions may prefer to be financed mainly from regional funds, as they are at present, and become regional universities. The centres at Zaria, Vom and Enugu could continue to receive federal support to develop faculties of technology, agriculture and veterinary science, and would become federal universities, as University College, Ibadan, has always been. It is unlikely that the regional universities would become in any way academically inferior to the federal universities, especially if the new institutions seek the sponsorship of well-established universities overseas. The relationship between the University of London and University College, Ibadan, has proved invaluable in establishing high academic standards. The federal and regional universities would be complementary: the more expensive medical and technological faculties being in the Federal institutions, while the regional universities could develop characteristics of the particular needs and traditions of their regions. Both types would be autonomous, and both would admit any suitably qualified student.

Of the 2,000 students who will graduate annually, there will be 800 teachers, 600 technologists, and 200 doctors; 200 will have agricultural or veterinary qualifications and 200 will have commerce degrees. The Commission deals with the training of these groups in detail, except for the technologists, who form 30 per cent of the total output. It would be particularly helpful to know what proportions should be trained in metallurgy, chemical, civil, mechanical, and electrical engineering, mining and other technologies, so that an estimate can be made of the size of the departments which are needed in the universities. Until a more detailed survey of man-power needs

has been made, it is difficult to make these estimates accurately.

One-half of the annual output of graduates must go into either teaching, agricultural, or veterinary appointments. At present these are the professions which receive the fewest numbers of graduates. It seems unrealistic to suppose that sufficient undergraduates will elect to prepare for the B.A. (Education) degree, or for agricultural or veterinary degrees, unless there is some substantial inducement. Since the success of the whole programme depends so much on an adequate flow of graduates into these professions, more detailed recommendations on this point, based on the experience of members of the Commission, would be helpful.

There is one danger which the report does not stress sufficiently strongly. This is that the universities, in expanding rapidly to meet a need for trained men and women, may tend to become centres where knowledge is disseminated rather than places where knowledge is acquired. This is simply to say that great stress must be laid on research. This is particularly the case in arts, science and technological faculties offering general courses, which will be much less specialized than those for single honours degrees. To maintain a balance and a high level of scholarship good research facilities must be provided. Only with these provisions will expatriates and Nigerians of high calibre be attracted to staff the universities, and will Nigerians be trained to replace gradually the expatriates. For some years to come, the burden of this training must fall on University College, Ibadan. In connexion with research facilities, a most welcome suggestion is that each university should have a Research Institute of African Studies attached to it.

The proposal to found a new university at Lagos, which would have two main constituent schools: Commerce and Business Administration and also Economics and Social Sciences, is a sound one. As the Commission points out, in an under-developed country, the universities must accept the responsibility of training accountants, bankers, transport executives, etc., because facilities for training 'on the job' are so lacking.

The Commission has faced squarely three other aspects of the educational programme. These are the provision of sufficient secondary school places, particularly in sixth forms; creating a virtually new teacher-training programme; and expanding technical institutes which will give training at an intermediate level. The problems which may arise here will result mainly from the rapid growth and sheer size of these projects.

These aspects are quite as important as the university development, for the whole is an integrated programme. The Commission has been bold and imaginative in its approach to Nigeria's educational needs. For the country's proper development ways must be found to make the plan succeed as a whole. It is sincerely to be hoped that international aid on a large scale will be forthcoming to help this "awakening giant of Africa", as Nigeria has been so aptly called.

# COTTON IN INDIA

**Cotton in India**

A Monograph. By B. L. Sethi, S. M. Sikka, R. H. Dastur, P. D. Gadkari, R. Balasubrahmanyan, P. Maheshwari, N. S. Ranga Swamy, and A. B. Joshi. Pp. xiv+474+30 plates. (Bombay: Indian Central Cotton Committee, 1960.) Rs. 30.; 45*s*.

THIS is the first of four volumes of a monograph, "Cotton in India", in which the Indian Central Cotton Committee is gathering together all available information in the domains of cotton culture, technology and marketing. The present volume is mainly concerned with research work in India, but gives a creditable, if not always critical, survey of the work done in other countries. The eight chapters cover the subject-matter as follows: history of cotton (B. L. Sethi); climate and soils (S. M. Sikka and R. H. Dastur); taxonomy (P. D. Gadkari); morphology (R. Balasubrahmanyan); embryology (P. Maheshwari and N. S. Ranga Swamy); breeding (S. M. Sikka and A. B. Joshi); genetics (S. M. Sikka and A. B. Joshi).

There is great need for a monograph of this kind, since cotton cultivation in India occupies an area of about 20,000,000 acres—about six per cent of the whole arable area. There are extensive and well-planned schemes of research in all the widely scattered cotton-growing areas. Large numbers of young and enthusiastic workers are without facilities for consulting the relevant literature. An encyclopaedic work of this kind, for the most part soberly and factually written, will be of great use not only to Indian workers but also to those in other countries, especially as the authors have avoided the parochial attitude of over-emphasizing Indian contributions, which indeed often represent pioneer work of great merit.

On the whole the authors have done their task well, and have produced a work of great value. There are a few errors of emphasis and interpretation; for example, the term genetical erosion is used in a wrong sense. It does not, as Sikka and Joshi imply, mean the breakdown which occurs in the second generation of interspecific crosses. It means the impairment of primitive adaptive complexes through extensive substitution of genes in the processes of selection or domestication. The first exploitation of the back-cross method is ascribed to Harland and Pope, instead of Harlan and Pope.

It is only to be expected that exuberant optimism will at times lead authors to express favourable opinions on future possibilities which are scarcely justified by existing scientific information. Thus, on p. 38, the reader is given to understand that sea island cotton can be grown successfully on the west coast (Kerala). It is, however, well known that the establishment of a sea island industry in this region would encounter almost insuperable obstacles of climate, soils, pests and disease. Its ultimate success is therefore doubtful. The main tasks of the breeders in India are first to increase yields to a level comparable with other cotton-growing countries, and second, to breed cottons which will spin good 40's. At present such cottons do not exist except perhaps occasionally in small experimental lots.

The book is well produced and relatively cheap. The index is poor, and there is no author index.

S. C. Harland

## MINERAL PROCESSING

### Proceedings of the Second United Nations International Conference on the Peaceful Uses of Atomic Energy

Held in Geneva, 1 September–13 September, 1958. Vol. 3: Processing of Raw Materials. Pp. ix+607. (Geneva: United Nations; London: H.M. Stationery Office, 1958.) 64 Swiss francs; 106*s.*; 15 dollars.

THIS volume is a collection of seventy-eight papers, each dealing with some aspect of the technology of winning and processing the ores of metals of interest in the field of atomic energy. A group of three papers deals with the methods of mining used for obtaining uranium ores in North America. Five are concerned with mathematical aspects of evaluating ore deposits and nine with instrumental methods of detecting and estimating radioactive materials, including potassium salts. The rest of the volume is concerned almost entirely with chemical aspects of mineral processing and physical methods of analysis for uranium, thorium and beryllium. There is also a valuable review of the chemical methods available for estimating uranium.

Very little work is reported on physical methods of ore concentration, so presumably the conventional techniques have proved adequate. An automatic method of sorting uranium-bearing rock using the radioactivity of desirable pieces to identify them is described, however, and there is an account of a normal type of process for separating the constituents of a beach sand containing monazite. There has also been limited interest in flotation as a means of concentrating minerals relevant to the Conference except in special cases. One of these concerns a lode deposit of monazite in South Africa which could not be treated by electrostatic and magnetic methods and another is, of course, the difficult problem of the separation of beryl from the other silicates which accompany it in Nature. The paper dealing with the latter topic shows with particular emphasis that valuable as the information presented at this Conference may be, there is much that is not given. Thus a large amount of data on the use of carboxylic acids, such as oleic acid, for separating beryl is given, followed by a table showing very much better results. These are said to have been obtained using a "special procedure"; but whether this means that the same reagents were used in a different way or that other reagents are better than those described in the paper is not clear.

Pretreatment of uranium ores before dissolving out the uranium has not been necessary in most cases, and is scarcely likely to be economically possible in the near future. However, a large amount of the known potential uranium reserves occurs as very low-grade ore, and three papers deal at least in part with the flotation of uranium minerals. The most active field of work in uranium mineral processing has undoubtedly been the study of methods for dissolving the uranium and recovering it from the resulting aqueous solution. Leaching either with acid or carbonate–bicarbonate mixtures has received about equal attention, and although the chemistry of both processes is well understood there are some interesting accounts of their application to particular ores. The work designed to produce an oxidizing sulphuric acid solution suitable for use as a leaching reagent by oxidation of sulphur dioxide in the presence of manganese or ferric ions as catalyst is worthy of particular attention.

Recovery of uranium from solution is carried out by solvent extraction or ion exchange, and there is a comparison of the relative merits of the two processes in various circumstances. Considerable interest in the treatment of unclarified solutions using the resin-in-pulp method or solvent extraction of the slurry is shown by the number of papers on these subjects. This is due to the difficulty of removing the suspended solids, and one communication deals with the use of flocculating agents to assist in this process. Of interest also is the method of reducing uranium in solution to precipitate the dioxide, using hydrogen with nickel or uranium dioxide as catalyst.

Chemical methods of cracking minerals are not confined to uranium treatment, of course, but few other cases are dealt with. There are, however, papers dealing with the breaking down of thorium minerals and of zircon.

It is unfortunate that the volume contains no index and that few of the papers include a summary. In spite of this, however, the book should prove valuable to anyone wishing to gain an idea of recent advances in the hydrometallurgical processing of minerals.

A. R. BURKIN

## ELECTROMAGNETISM AND RELATIVITY

### Les Principes de la Théorie Électromagnétique et de la Relativité

Par Prof. Marie-Antoinette Tonnelat. Pp. 394. (Paris: Masson et Cie., 1959.) 5,000 francs.

THIS text-book is divided into three parts, dealing with electromagnetism, special relativity and general relativity. The section on special relativity is the largest and the most complete part of the book. It sets out the historical development of the ideas and concepts which led, in the end, to the special theory, and it traces very carefully the interplay between the theoretical concepts and the few decisive experiments during the course of this development.

The main factors on the theoretical side were very straightforward. First, Newton's equations of motion and the Galilean invariance which resulted implied that no (inertial) reference system had preference over any other system moving uniformly relative to the first. Then, later, the nineteenth-century ideas on the propagation of light appeared to single out one absolute reference system, which was specified by the ether. Later again, it was seen that Maxwell's equations were not Galilean invariant, and therefore they, too, supported the idea of the absolute reference system. Thus it seemed that all that was needed to determine absolute motion was a few accurate optical experiments. However, the culmination of these experiments was the famous interferometer work of Michelson and Morley, which gave the nul result.

This story is well told, with adequate digressions to deal with related matters of interest. For example, the relation is pointed out between the experiments of Fizeau, Hoek, and others on the propagation of light in moving media, and the experiment of H. A. Wilson on the effects of moving a dielectric in a magnetic field. In addition, the mathematical appara-

tus of special relativity is developed in a very complete treatment, and numerous applications of the special theory are given.

Unfortunately, the book could not contain an account of the recent work of Terrell and of Penrose[1] on the Lorentz–Fitzgerald contraction. A fast-moving object, it is well known, is contracted in the direction of its motion by a factor $(1-v^2/c^2)^{1/2}$. Thus, for example, a fast-moving cube becomes a rectangular parallelepiped with the shortest principal axis along the direction of motion. However, Terrell and Penrose have pointed out that this is not what an observer would see. For example, an observer at right angles to the line of flight of the cube would see the rear face of the cube as well as the face nearest to him. The result is that the cube appears to the observer to be rotated, but undistorted. (This is true provided the cube subtends a small angle at the observer.) The Lorentz contraction is nevertheless still valid. If $(v/c)$ is close to unity, the face nearest the observer has shrunk to zero width, but the observer sees the rear face at full size.

The section on electromagnetism contains a rather formal treatment of Maxwell's theory; for example, the electrostatic properties of conductors are derived before there has been any discussion of the presence of electrons in conductors. Indeed, the main purpose of this section appears to be to emphasize that electromagnetic phenomena can be described entirely by fields rather than by action at a distance.

The final section is that on general relativity. Here there is a good mathematical treatment, with several interesting worked examples, and an adequate physical discussion. However, it is at this point that one would expect some discussion of fairly new ideas and developments. Some comment might be expected on whether we can hope to detect gravitational waves, what is the present status of theories of the expanding universe, whether we should expect there to be anti-galaxies, and whether the latter have reversed gravitational interaction with ordinary galaxies. Discussion of some of these topics might perhaps have been more rewarding than the account of the unified theories of gravitation and electromagnetism with which the book concludes.

J. Hamilton

[1] Penrose, R., *Proc. Camb. Phil. Soc.*, **55**, 137 (1959). Terrell, J., *Phys. Rev.*, **116**, 1041 (1959).

## ESSENTIALS OF LOGISTICS

### A Précis of Mathematical Logic

By J. M. Bocheński. Translated from the French and German editions by Otto Bird. (Synthese Library.) Pp. ix+100. (Dordrecht: D. Reidel Publishing Company, 1960.) 13.75 D. fl.

One of the most remarkable features of twentieth-century thought is the immense creative effort of Polish scholars in the field of mathematical logic. In this, of course, they are by no means alone, since (among others) Italy, Great Britain and the United States have contributed vital elements to the growing structure. Nevertheless, there is something intrinsically majestic about the Polish work, both in the profundity of research, and in the wide range of studies. Having enriched what they have touched, they have become scholars in analysis and artists in symbolism.

This means that, sooner or later, it becomes desirable to 'tidy up', that is, to tabulate with extreme formality the propositions and theorems which the power of the new 'logistik' has produced. The result is the slender volume before us, a masterpiece of condensation and taxonomy. A touch so appropriate to a book of this character is that the introduction starts with paragraph zero, so that "Fundamentals" begin with paragraph 1, and onwards; the decimal notation is correspondingly simplified throughout.

The arrangement is: (1) "General Principles"; (2) "The Logic of Sentences"; (3) "The Logic of Predicates and Classes"; (4) "The Logic of Relations"; (5) "Varia". At the end are a table of logical signs and an exceptionally full bibliography. This latter will be welcomed as a reinforcement of the literature listed from time to time in *The Journal of Symbolic Logic*.

A further aid to the student is a short summary, at the conclusion of each section, dealing with the history and literature of the particular aspect under discussion, for example, laws and rules, predicates, the theory of identity, syllogistics and so on. It is interesting to note that the first of these originated with Husserl's distinction; Aristotle thought of his theorems as laws, whereas to the stoics and scholastics they were rules.

There is a clear account of the newest branch of the subject, namely, the logic of relations, which is capable of extension over perhaps the whole of knowledge. Even at the present early stage of development its fundamental connexion with geometry begins to appear.

The value of this précis lies in its power to bring the main results of logistics into exact focus, so that they can be seen both in derivation from classical principles and in terms of contemporary notations. Denuded of verbiage, it is remarkable how many of them were known to the Greek philosophers and to medieval savants. Yet the modern discipline (including in particular the many-valued logics) is of incomparably greater force, as well as possessing enhanced importance in advanced mathematical education.

F. I. G. Rawlins

## CATALYSIS

### Catalysis, Vol. 7

Oxidation, Hydration, Dehydration and Cracking Catalysts. Edited by Paul H. Emmett. Pp. vi+378. (New York: Reinhold Publishing Corporation; London: Chapman and Hall, Ltd., 1960.) 108s. net.

The publication of this final volume of a major work dealing mainly with industrial catalytic reactions will be welcomed by the many chemists who are interested in this rapidly moving field; and Prof. Emmett and the individual contributors are to be congratulated on making available, in a convenient form, summaries of the very large mass of material, having largely an industrial bias but relating also to some academic applications of catalysis, which lies scattered and difficult of access in the patent and journal literature.

In the first chapter of this volume, L. B. Ryland, M. W. Temele and J. N. Wilson, of Shell Development Co., deal with the use of modern fluidized and other finely divided catalysts for the cracking of crude petroleum into lighter oils. This is followed by a long section on catalytic hydration and dehydration, by M. E. Winfield, of the Commonwealth Scientific and

Industrial Research Organization, who has himself been responsible for much work on this subject. The remainder of the volume has been written by J. K. Dixon and J. E. Longfield, both of the American Cyanamid Co., who give, in successive chapters, an account of the partial oxidation of hydrocarbons, mainly on catalysts of the vanadium pentoxide or metallic platinum types, detailed attention being given to the theoretical aspect of these reactions. This is supplemented by two further chapters on the mechanism of catalytic oxidation generally and by a rather disappointingly short section on miscellaneous catalytic oxidations.

The spreading of the publication of the complete work over some six years (the first volume appeared in 1954) has necessarily rendered some of the volumes to some degree out of date and incomplete; but this is inevitable in a rapidly moving subject, and Prof. Emmett has probably acted wisely in publishing the material as it was received. The now complete work is to be strongly recommended as a necessary acquisition both by technical and academic libraries and by individual chemists. It will be found to be an exhaustive source of reference in almost all branches of modern catalysis, and should be particularly useful as a foundation for further research.

E. B. MAXTED

## EVOLUTION

### Implications of Evolution

By Dr. G. A. Kerkut. (International Series of Monographs on Pure and Applied Biology. Division: Zoology. Vol. 4.) Pp. x+174. (London and New York: Pergamon Press, 1960.) 30s. net.

DR. KERKUT begins his book with seven 'assumptions' which he thinks are implied in any acceptance of the theory of evolution. The first three of these are that non-living things gave rise to living material, that this happened only once, and that all living things—viruses, bacteria, animals and plants—are interrelated. Even if we read conclusions in place of assumptions, it is by no means true that all or even a majority of the biologists who believe in evolution would accept any of these as necessarily true or as implied in their belief. Evolution is the theory that in the history of life change has taken place by 'descent with modification', and the study of the course of change is phylogeny, not the theory of evolution. If we accept evolution, it by no means necessarily follows that phylogeny is monophyletic, and certainly not that any conclusions about the origin of life are implied.

Dr. Kerkut's aim in the main part of his book is to show that these 'assumptions' are ill founded, especially that we have no good reason to believe that the viruses, bacteria, rickettsias and higher organisms are related, or that the invertebrates, and even the vertebrate classes, are monophyletic. Though our views on these questions have little bearing on our belief in evolution, they are certainly questions of interest, and it is good to have them discussed by one who disagrees with widely held views. But any discussion of such questions, if it is to carry weight, must be on a fair consideration of all the relevant evidence, and I cannot agree that Dr. Kerkut gives us that. He does not discuss all the evidence, and not always the parts of the evidence that seem weightiest to most biologists. To take one example, in considering the morphology of the cell as indicating that all animals are related, he mentions only the mitotic figure—itself one might think strong enough evidence, though he does not agree—and says nothing of the rest of cell morphology—the visible and submicroscopic structure of the cell and nuclear membranes, Golgi apparatus, mitochondria, etc. It is on these many similarities, together with other evidence, that most biologists think that the cell cannot have been evolved more than once.

Other objections to the argument of the book might be raised, but to me the most general criticism is that evidence that bears against its thesis is often not discussed. As Darwin so well realized, one is much more likely to convince by over-stating one's opponent's arguments and answering them, rather than by passing them by without discussion. On these grounds the arguments of this book cannot, in my view, be thought conclusive. It is well produced; misprints, though they occur, are not especially numerous.

G. S. CARTER

## ZOOLOGICAL LITERATURE FOR 1957

### The Zoological Record

Vol. 94: Records of Zoological Literature relating chiefly to the year 1957. Edited by G. Burder Stratton. Pp. 1842. (London: The Zoological Society of London, 1960.) 160s.

THE orange-coloured bindings of the "Zoological Record" stand out in any library, for they have been coming out for nearly a century and now occupy many feet of shelving. The volumes have changed very little over the years, and the present one—Volume 94, referring mainly to the literature of 1957—retains almost the same format and the somewhat out-dated system of classification of the earlier numbers. Vermes, for example, is almost Aristotelian in its breadth, and includes Platyhelminthes, Nemathelminthes, Rotifera, Annelida, as well as an assortment of smaller groups. However, there are certain advantages in changing as little as possible a reference work of this nature, and the sections into which it is divided are conveniently arranged, so that any person consulting the "Record" will have no difficulty in finding the publications on any particular subject or by any author, with the least possible delay. The contents, apart from their general usefulness to all workers in the subject, are also of interest as a rough indication of trends in zoological research work, based on the number of publications in the various sections. These trends are difficult to understand, for while Insecta remains by far the biggest section, Mollusca now takes second place although its economic or medical significance is somewhat limited. Owing to difficulties of recording, the sections dealing with Amphibia and parasitic Protozoa have not been included in the present volume, but it is hoped that they will appear in the near future.

Zoologists throughout the world are greatly indebted to the Zoological Society of London for undertaking the publication of this invaluable compilation with such little delay, for most of the sections of Volume 94 were available in 1959 and three even in 1958, the year following the literature to which they refer.

EDWARD HINDLE

# RADIOACTIVE FALL-OUT IN ISRAEL RESULTING FROM THE NUCLEAR TESTS IN THE SAHARA DESERT

By Y. FEIGE, E. SHALMON and J. VARDI
Health Physics Department, Israel Atomic Energy Commission

J. R. GAT (GUTMANN)
Weizmann Institute of Science, Rehovoth

AND

Y. L. TOKATLY
Israel Meteorological Service

ON February 13 and April 1, 1960, nuclear test devices, reportedly in the kiloton range, were exploded in southern Algeria. These tests followed a prolonged period during which no nuclear tests were conducted, with the result that fall-out of short-lived fission products had decreased to a very low level. The tests offered an opportunity of observing fall-out from isolated and well-defined sources of activity in this area.

Radioactive materials resulting from these tests were first picked up by the Israel Fall-out Monitoring Network on February 17, and were repeatedly observed again during the following months. The interpretation of the resulting fall-out deposition pattern in the light of the meteorological data gives some insight into the movement of radioactive 'clouds' and their mode of deposition of activity.

## Measurement of Fall-out

The Israel Fall-out Monitoring Network has been described by Gat and Gilat[1]. It consists of seven sampling stations where activity deposited on gummed tape is collected. The stations are situated throughout the country from Eilath on the Gulf of Aquaba to Upper Galilee, and cover hill and valley areas. In addition, air filtration is carried out at ground-level at Rehovoth with the aid of Staplex type air-pumps and a continuous air monitor. The β-activity accumulated on the samplers during the exposure period is counted on the third day after collection (after the decay of short-lived natural activity) and again at fixed time-intervals thereafter. The counters are standardized by the radiation from potassium-40 in natural potassium chloride, following accepted practice. The homogeneity of the deposited activity and the presence of 'hot particles' is determined by autoradiography of the ashed samples.

## Fall-out Pattern and its Correlation with Meteorological Data

The results of deposition measurements from five of the stations are plotted in Fig. 1 where some of the pertinent local meteorological information is also given. Fig. 2 shows the decay of some representative samples plotted on a log activity versus log time-scale, with the reported explosion dates taken as the time origin. The decay data enables one to relate the activity peaks to the first, second or to previous nuclear explosions.

The main impact of the first nuclear explosion was detected in Israel on February 17. On this day a fairly large number of discrete hot particles was collected on the gummed tapes, resulting in a deposition of activity of about 25 mμc./m.$^2$ (activity on fourth day after collection).

The meteorological synoptic maps of that day show the passage over Israel of a cold front associated with an eastward moving centre of low pressure which had developed over the central Mediterranean some days before. The upper air at 500 mb. had flowed from the explosion region towards this 'low', continuing to move with it (Fig. 3). The front which coincided with the deposition of activity was more diffuse in the southern part of the country, as was reflected in the spreading out of the activity peak at the Eilath station. (Due to an oversight, the gummed tape of February 16 was not changed at Jerusalem until noon of the following day. Hence the activity shown on the tape of February 16 apparently includes that of the following day.)

On February 18, fall-out values returned to normal levels everywhere except at Eilath where the trailing edge of the cold front was still effective, and at Jerusalem where one single 'hot' particle was collected. (It cannot be established with certainty whether this single particle is due to some residual activity which remained aloft or whether this is a blow-over particle from material deposited on the previous day.)

During February 20–21 and again on February 24–25 anticyclonic cells, moving in a north-easterly direction from the Western Desert, passed over the Levant. Both occurrences were associated with some deposition of fall-out. Backtracking of the air masses shows that their probable source was low-altitude air ($< 3$ km.) near the test site. Air circulation had been stationary over the whole of North Africa during this period. From these more or less stationary air masses over North Africa 'bubbles' were detached, in conjunction with the formation of anticyclonic cells, which slowly moved north-eastward into the Mediterranean and over Israel (Fig. 4).

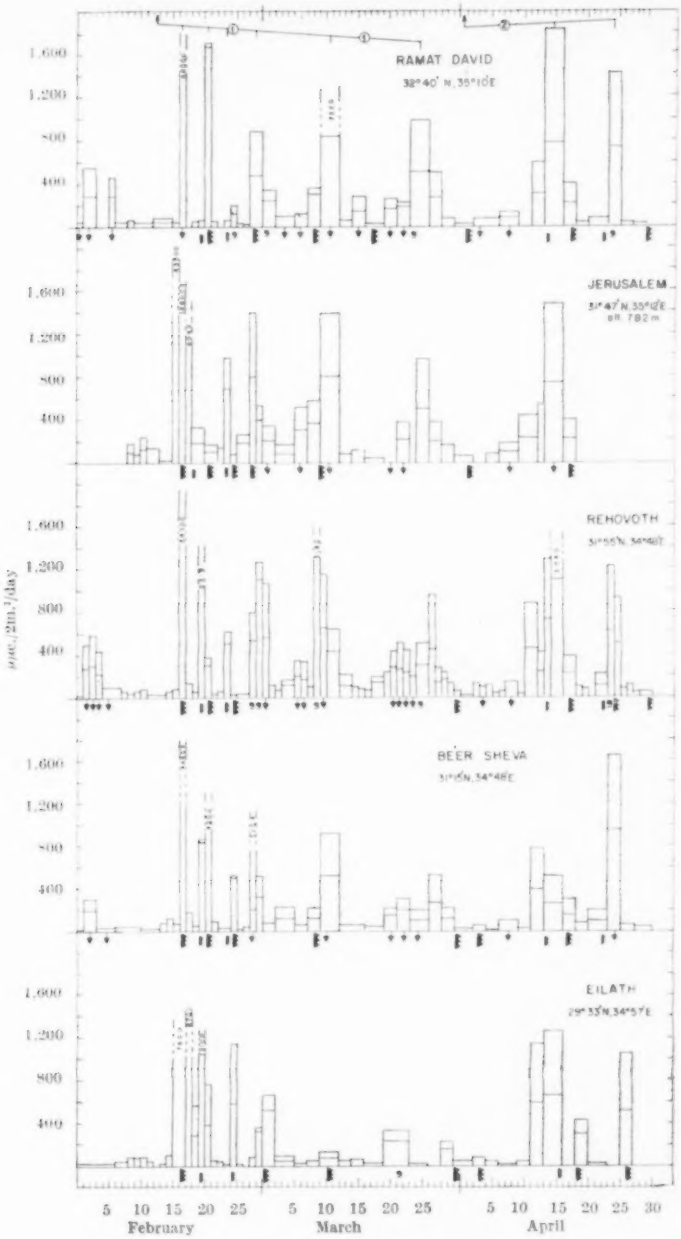



Fig. 1. Deposited fall-out activity at five 'gummed tape' collection stations in Israel, February–April 1960. (Activity on fourth day after collection)

Meteorological symbols : warm front ; cold front : ; drizzle

The origin date of the activity peaks, as determined by decay measurements, is indicated on the top of the diagram

The passage of a marked cold front accompanied by rainfall on February 28 resulted in an appreciable deposition of activity throughout Israel. This front also trailed back and diffused in the south of the country. Backtracking in the 500-mb. layer shows that air in this layer had passed over the Sahara some days before. Since there is apparently no alternative contamination source, we postulate that this air had picked up activity by vertical mixing from the near surface air while passing over the

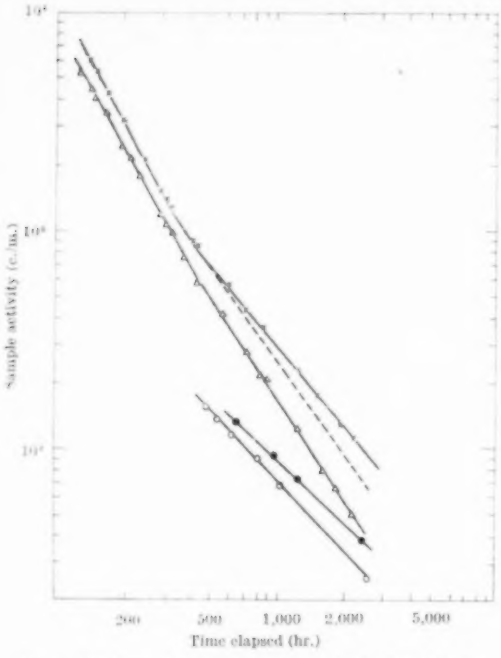



Fig. 2. The decay of representative samples of fall-out activity. △, Activity deposited on 'gummed tape collector' at Rehovoth, on February 17, 1960 (time origin February 13); ×, activity collected by air filtration at Rehovoth on February 17, 1960 (time origin February 13); the broken line shows the decay of the sample corrected for the presence of an average amount of long-lived background activity; ○, activity deposited on 'gummed tape collector' at Rehovoth on April 15, 1960 (time origin April 1); ●, activity deposited on 'gummed tape collector' at Tirat-Yael on April 24–25, 1960 (time origin April 1)

Sahara. It is worth while to note that this assumed mode of transport resembles the mechanism whereby activity from the Windscale release reached Western Europe[4].

During the first week of March good deposition conditions (rain) occurred on a number of occasions, without fall-out being observed. On March 9–10, however, activity was brought down by rainfall, presumably from a nuclear 'cloud' which had circled the Earth with the prevailing westerly winds of the upper troposphere (at an average rate of 65 km./hr.).

During the second half of March unstable cold air caused precipitation throughout the country which was not accompanied by much activity. From March 26 onwards hot desert air moved in from the south, gradually building up sharav conditions. ('Sharav' is a period of hot and dry weather caused either by subsidence owing to the persistence of an anticyclone over the area or by advection of desert air from the Arabian Peninsula or the Syrian Desert.) The presence of this air mass resulted in a substantial increase in the deposition-rate of activity. Peak activities were recorded on March 26 and 27 in the northern part of the country. There was notable deposition even though subsidence conditions prevailed, so that there was no vertical air exchange in turbulent drafts. The influx of cold air during March 30–31 which replaced the hot and contaminated air terminated the heat wave as well as the fall-out.

The deposition pattern of fall-out from the second nuclear test explosion differs in some respect from that described above. No fall-out was detected here during the first ten days following the test in spite of the fact that two cold fronts, accompanied by some rain, passed over this area. This result is in agreement with the fact that the streamlines of upper air (above 3 km.) were due eastward from the test site and therefore probably carried debris on a more southerly route than the one followed after the first test explosion (Fig. 5). The near surface air (up to 1·5 km.) near the test site was, however, seemingly trapped in the desert for some days by a 'high' which extended over Lybia at that time. On April 6 some of this air formed an anticyclonic cell which reached Israel on April 13, its edge advancing as a warm front northward on April 14 and 15 (Fig. 6). The radioactivity measurements (Figs. 1–2) show that this desert air carried with it some activity from the second test. Its slow northward advance is clearly reflected in the results of fall-out measurements of the stations in the south and north. The fall-out came to an end on April 17 on the arrival of cold air from the west. The additional activity peak recorded on April 24 (except at Eilath, where its appearance was delayed) can perhaps be attributed to the passage of a nuclear cloud from the second test explosion which had circled the Earth. This deposition of activity occurred during the passage of a cold front. The decay-rate of the deposited activity is similar to that of activity deposited during the week of April 12–18.

No further significant deposition-rates were recorded up to August 1, 1960.

## Air Activity Measurements

The radioactivity of particulate matter in the surface air as determined at Rehovoth Station by air

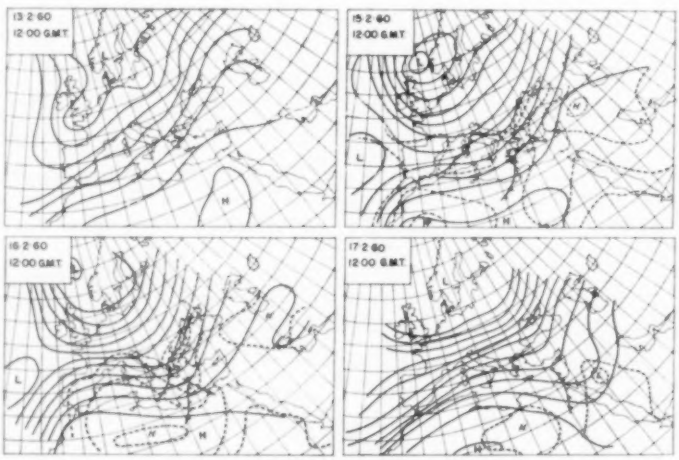



Fig. 3. Upper air streamlines and synoptic maps following the first nuclear test. Solid lines, 500 mb. streamlines; broken lines, surface isobars; cold and warm fronts are indicated in standard way

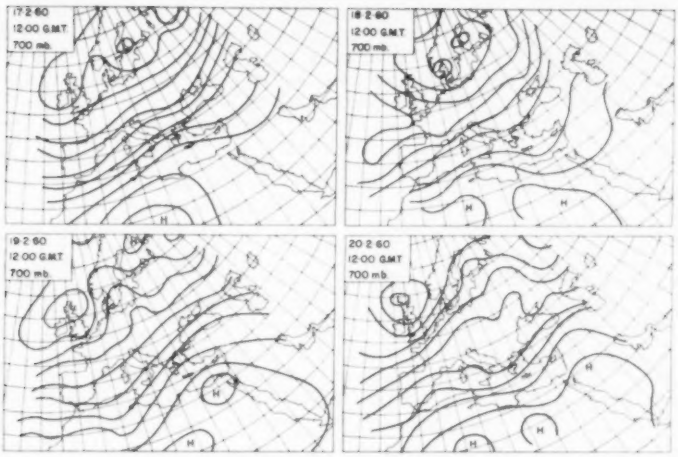



Fig. 4. Streamlines of 700-mb. layer, showing the formation of anticyclonic cells over North Africa and their trajectory into the Levant

filtration with Staplex- and Victoreen-type air pumps, is shown in Fig. 7. It should be noted that the air activity diagram shows less variations than the corresponding 'deposited activity' diagram. There is an appreciable long-lived activity background of about 0·08 μμc./m.³. Marked increases in the air activity were observed only on February 17, March 9, during March 13–14 and March 27–31, on April 14 and 15 and on April 24. Only the peaks of February 17, March 9 and the April activity peaks have their counterpart in the deposited activity diagrams. The decay of the activity collected on these days is very similar to that of the activity deposited on the gummed tape collector, if one takes into account the long-lived background activity (Fig. 2). The decay-rate of the activity collected on the other peak days shows that little activity of recent origin is included in these samples. The relative sizes of the air activity peaks (ratio of signal to average background) recorded on the air monitor after the first nuclear test are smaller by two orders of magnitude (a factor of 30 on the Staplex pumps) than the corresponding peaks of deposited activity, but are about equal for the peaks detected during April following the second nuclear test.

## Discussion

Deposition of nuclear weapon debris resulting from the Sahara tests was noted on rainless days only when one of two distinct meteorological conditions prevailed: during the passage of cold fronts or during the sojourn of air from anticyclonic cells moving in from the African continent. The deposition pattern was quite different in these cases.

The cold fronts resulted in large amounts of activity being deposited during a short time-interval, the amount apparently depending on the temperature gradient of the front. The observation of activity at ground-level is in this case made possible by the existence of a vertical transport mechanism active to a height of a few kilometres. The coincidence between all measured activity peaks and the existence of such a mechanism shows that no activity can be detected at ground-level unless two conditions are satisfied: (1) The presence of a 'nuclear cloud' aloft; (2) the existence of an atmospheric transport mechanism reaching up to the height of the cloud. It follows that the extent of the nuclear cloud aloft cannot be determined from the duration of the deposited activity peak.

On the other hand, the radioactivity carried by the warm air cells appears in the form of broad peaks on the deposited activity diagrams. Activity was detected even in the absence of any distinct mechanism for vertical air exchange. The duration of these peaks is therefore determined by the time of stay of the contaminated air masses in the area.

Each of the activity peaks recorded during the period under discussion was associated with air which was tracked back directly to the vicinity of the test site, either through the surface or upper-air layers. Meteorological systems which brought air along different tracks during this period contained no measurable amounts of (recent) fission product activity. This simple deposition pattern is probably the result of the tendency of the air-flow to be zonal during this period. The high circulation index indicates the lack of transport of radioactivity on a large scale across latitudes, except for one occasion when a northward protrusion of an upper ridge of high pressure extending from North Africa to Europe may have been responsible for the activity peak reported in the United Kingdom between February 28 and March 1[3]. Judging from our experience with the flow regime observed following the tests, it

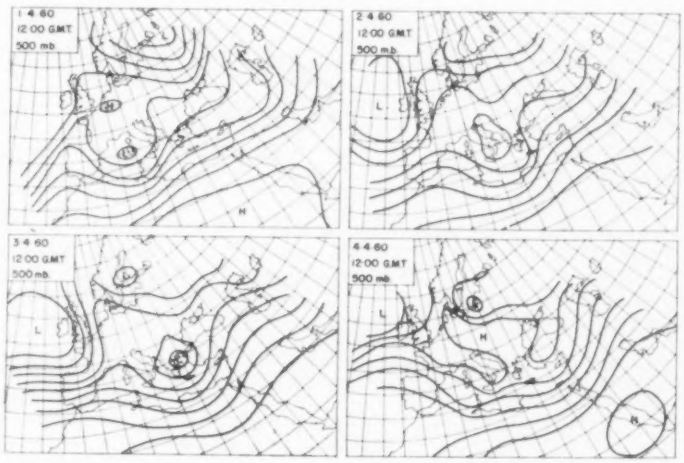



Fig. 5. Upper air streamlines following the second nuclear test

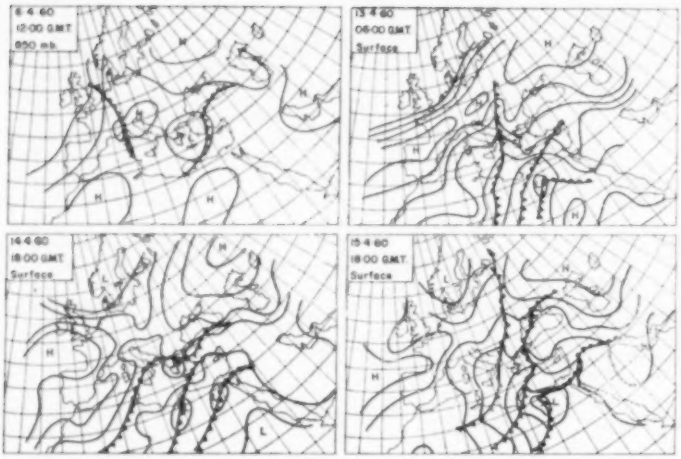



Fig. 6. Map 1: typical synoptic situation which results in activity being confined over North Africa. Maps 2–4: surface pressure distribution (during period April 13–16) showing the development of an east-moving low across the North African coast which caused this activity to move into the Levant

appears that synoptic data are sufficient in a simple meteorological system to forecast quite accurately the transport of radioactivity in the weather layer. This, however, may be very difficult where more complex meteorological systems develop.

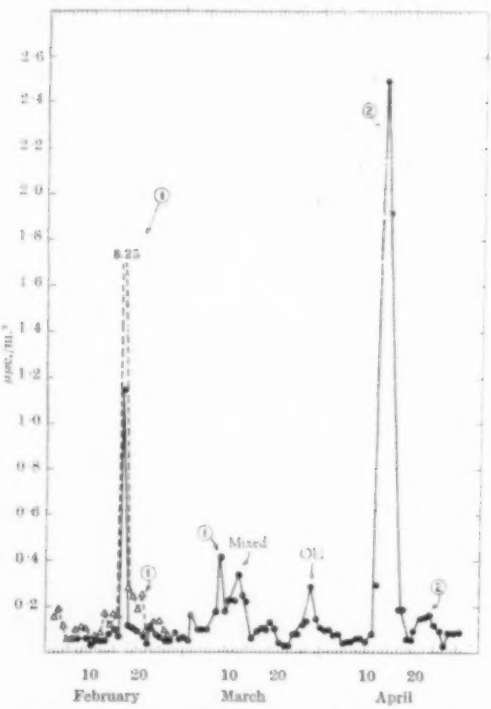



Fig. 7. Activity of particulate matter in surface air at Rehovoth Station, February–April. (Activity is given in units of $\mu\mu c./m.^3$ on fourth day after collection.) △, Staplex air pumps with *TP.4* No. 41 filters; ●, Victoreen, Model 900–2, mobile air monitor. The origin of the activity peaks (first, second or previous nuclear test) is indicated

The surprising result of the measurements is the fact that, for more than a month following each test, every air mass which reached Israel after having been in contact or in exchange with near-ground-level air of the Sahara contained radioactivity. The localized persistence of the radioactivity in the air above the Sahara, inferred from this result, is noteworthy. It is undoubtedly due to the aridity and the semi-stagnant air circulation pattern of the region and hence a peculiarity of the dates and location of the tests. The results of radioactivity measurements at Ghana, reported by Ward and Marr[4], confirm the continuously high air count of the desert air up to the beginning of March.

The debris from the first nuclear test was detected much more efficiently on the gummed tape than by the air pumps. It behaves quite differently in this respect from the material from the second test as well as from the residual airborne activity which is responsible for the appreciable background count on the air-filters but is barely detectable on the gummed tape.

The gummed tape collector is considered (except during showers) to be a sampler of large-sized particles only. The air-filters, on the other hand, are known to be effective in collecting fine particles (larger than 0·01μ). The Staplex type air pumps when set up horizontally with these filters are, however, poor collectors of coarser grain particles at the flow-rate used; the continuous air monitor having a curved inlet pipe is even less responsive to the larger particles.

From the different response of the sampling equipment to debris from the two test explosions it is inferred that the debris materials differ considerably in the size distribution of the radioactive particles. The results may be interpreted in terms of (size) spectral shift to larger particles of the atmospheric radioactivity associated with the first nuclear test, relative to the residual atmospheric radioactivity which is responsible for the background counts. This seems to be true for the peak of February 17 as well as for subsequent peaks related to the first test.

Debris from the second nuclear test seemed to be in a more finely divided form. No hot spots were found, and the air monitor proved to be as responsive (signal to background ratio) as the gummed tape collector. The different size distribution of the debris from the two tests is probably related to the fact that the second explosion was an air drop whereas the first test was reported to be a tower experiment.

The results emphasize that the quantitative response of the conventional fall-out detection systems depends on the size distribution of the fall-out material at ground-level as well as on its concentration in the air. A number of discrepancies between air activity and fall-out deposition-rates seen in the literature[5] may find their explanation in the different sensitivity of different monitoring equipment to the size and shape of the aerosol particles. The possibility of detection at ground-level of fall-out material from higher-altitude layers depends, of course, with

any monitoring system, on the operation of favourable meteorological transport conditions.

The measurements show the 'gummed tape' to be an efficient collector of fresh nuclear test debris even on rainless days; the activity measured cannot, however, be quantitatively related to true air concentrations of fall-out.

The amount of activity deposited in Israel as a result of the nuclear tests in the Sahara turned out to be insignificant from a public health point of view; it contributed only a small addition to the fission debris accumulated as a result of previous nuclear test explosions.

We are indebted to the Director, Israel Meteorological Service, and to the staff of the Forecasting Division at Lod for the use of synoptic maps and to the Israel Atomic Energy Commission under the auspices of which the measurements were carried out.

[1] Gat, J. R., and Gilat, J., Israel Atomic Energy Comm., Rep. No. *IA*/571 (1960).
[2] Hinzpeter, M., Becker, F., and Reifferscheid, H., "Atomtechnisches Aerosol und Atmosphärische Radioaktivität", 57 (Gersbach and Sohn Verlag, Braunschweig, 1959).
[3] Anderson, W., Bentley, R. E., Burton, L. K., and Greatorex, C. A., *Nature*, **186**, 223 (1960).
[4] Ward, A. H., and Marr, J. D., *Nature*, **187**, 299 (1960).
[5] Lockhart, L. B., Baus, R. A., and Blifford, I. H., *Tellus*, **11**, 83 (1959).

# POST-SECONDARY AND HIGHER EDUCATION IN NIGERIA

By Dr. C. T. MORTIMER
University College of North Staffordshire, Keele, Staffordshire

"INVESTMENT in Education" is the title of the report of the Commission on Post-School Certificate and Higher Education in Nigeria*. Sir Eric Ashby was the chairman, and the Commission included American and Nigerian members. It was constituted to investigate Nigeria's needs in education over the next twenty years, and to recommend how these needs might be fulfilled.

The Commission's approach to the problem reflects the optimism which is to be found in Nigeria to-day. It thinks of the country as it will be in twenty years time: a nation of some fifty million people, with industries, oil, and a well-developed agriculture. To provide for this development the Commission's educational proposals are massive, expensive and unconventional. They include doubling the secondary school intake, creating a completely new teacher-training scheme, building six large technical institutes, and increasing the output of graduates from 300 to 2,000 a year; all in the next ten years. This would undoubtedly be beyond the present resources of the Federal and Regional Governments. Only with aid on an international scale can this educational 'crash' programme be accomplished.

A survey of the need for 'high-level' man-power, to enable Nigeria to carry out the programme of economic development, has been made by Prof. Frederick Harbison, of Princeton University. In this context 'high-level' man-power means men and women who have had education beyond school certificate. The minimum need, over the next ten years, is for 80,000 people with some post-secondary education. About 30,000 of these are described as "senior: managerial, professional and administrative", and a majority of them should be graduates. Some 50,000 people will be required with an "intermediate" qualification, calling for two or three years of full-time study after school certificate.

It should be emphasized that these estimates are a minimum which is required to permit the economic growth of Nigeria in the next decade to be equivalent to that in the ten years prior to independence. This has been only 4 per cent per annum in real terms. Moreover, even if this rate of economic growth is sustained, by 1970 Nigeria will still have a lower number of high-level man-power per thousand population than either Ghana or Egypt has at present. Also, during this time Nigeria's population will have increased by about one-sixth of its present number.

The report stresses, however, that in planning educational institutions, it is the rate of flow which is important. The objective is, therefore, to propose an educational machine which will produce at least 8,000 people per annum with some post-secondary education.

In 1958, about 600,000 pupils entered primary schools, which is a substantial proportion of the 800,000 who (at a rough guess) reach the age of seven each year. This represents almost univeral primary schooling in the Eastern and Western Regions, although in the Muslim Northern Region, where the development of Western education has been much slower, only about one-tenth of the young children attend primary schools. In order to fulfil Harbison's estimates, about 5 per cent of those who finish primary school (some 30,000 pupils) should enter secondary schools each year, with a view to slightly more than 1 per cent (8,000 pupils) eventually obtaining a post-secondary qualification. For these objectives to be achieved, four distinct, though interrelated, parts of the educational system must be strengthened or developed. These are: (1) the teacher-training programme; (2) the secondary schools; (3) facilities for technical training; (4) the universities. These topics the Commission considers in detail.

As in all undeveloped countries, much depends on the teacher-training programme. Both an emergency, short-term scheme and also more permanent facilities are recommended. At the base of the educational pyramid the first step is to give an "injection of remedial education" to some 8,000 primary and secondary school teachers, many of whom have only the most meagre of qualifications. This would be in the form of short residential courses of one or two months, held in the universities. The beneficiaries of these courses would be consolidated by a teacher-guidance service of about 1,000 experienced travelling teachers, most of whom would have to be expatriates, at least for some time to come.

* Investment in Education: The Report of the Commission on Post-School Certificate and Higher Education in Nigeria. Pp. v + 140. (Lagos: Federal Government Printer; London: Crown Agents for Oversea Governments and Administrations, 1960.) 5s. net.

More permanent training facilities will provide for Grade I colleges, offering a qualification which would be a minimum for secondary school teachers, and also Grade II colleges, which the majority of intending primary school teachers will attend. It is hoped that by 1970 the Grade II colleges, which now offer only a two-year post-primary education, will be upgraded and provide training up to school certificate level, together with the teaching certificate, and have an output of 18,000 teachers a year. These colleges will require a large number of graduate and Grade I staff. It is estimated that the output of teachers with the equivalent of Grade I status must be not less than 3,000 a year. The main avenue to this qualification must be two years of formal education after the school certificate, and involves finding 6,000 teacher-training places. The majority of the Grade I teachers will be trained in eight new colleges. The technical institutes will train about 500 teachers a year, who will teach manual subjects, which would become obligatory in all primary and secondary schools. This should help to correct one of the major defects in Nigerian education, namely, a strong bias towards the traditional literary and academic subjects, which is reflected in a lack of respect for manual skills and technical achievement. The training of graduate teachers is considered under the section dealing with the universities.

The secondary schools should be able to take about 30,000 pupils a year. At present there are facilities for only 12,000 entrants annually, so that 18,000 places a year must be created. This is equivalent to some 600 secondary school streams. From the 30,000 who will enter secondary schools, it is expected that 25,000 will obtain a school certificate, and of these 5,000 would proceed to some intermediate training, while 3,000 would continue with sixth-form studies, with the view of entering universities.

The Commission is strongly in favour of sixth-form work being carried out in secondary schools, rather than in special colleges, or in preliminary courses at the universities. At present there are sixth forms in only 22 schools, catering at most for 500 pupils a year, so that over the next decade another 100 sixth-form streams must be created (which, incidentally, will require at least 400 additional highly qualified teachers). But these sixth forms cannot wait until they are built up from the junior classes of new secondary schools. The Commission therefore recommends that national high schools be established, consisting initially only of sixth forms (the pupils being admitted from other schools in the area). In time junior classes would be grafted on. In addition, selected secondary schools should be encouraged to develop sixth forms.

It is estimated that some 3,000 technicians should be trained each year. The most efficient development of technical education would be to have about six large institutes in centres of population. For the next ten years the institutes at Enugu, Ibadan, Kaduna, Yaba, together with that planned for Benin City, that contemplated at Port Harcourt, and, it is hoped, one at Kano should suffice.

Part of this scheme is 'self-generating' and should produce, by 1970, enough men and women to staff the 18,000 Grade I appointments in primary and secondary schools, in teacher-training colleges, in technical institutes, and in the supervisory teaching scheme. It will provide entrants to the universities, some of whom will return to fill the 7,000 graduate teacher appointments. But unless some initial momentum is given the whole machinery will get under way too slowly. To "prime this educational pump" the Commission hopes it will be possible to import a corps of teachers into Nigeria on short-term contracts. Graduates would have to be engaged at the rate of 1,000 a year between 1962 and 1966. At the same time a group of Nigerians (some 600 a year) would be sent overseas for university training to prepare for teaching. This measure would produce enough Nigerians to replace the short-term, expatriate teachers by 1970. During this period it is hoped that the output of graduate teachers from Nigerian universities would rise to about 800 per year.

For the continued growth of Nigeria's economy at its present modest rate it is estimated that the country needs at least 2,000 graduates a year. The student population in Nigerian universities at present is about 1,500, and the output of graduates is 300 a year. Also, about 500 Nigerian graduates return each year from overseas universities. The Commission recommends that at least 7,500 student-places should be available in Nigerian universities by 1970. Three aspects of this proposed university expansion are considered in detail: the range of studies, the sites for new universities, their financing and government.

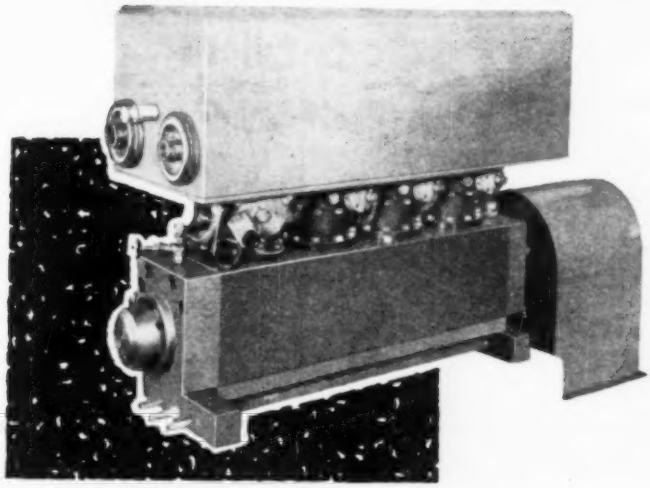
There must be more diversity and flexibility in university education than is found in the British system if it is to meet the needs of the Nigerian people. The British system of university education suits Britain because there are many alternative routes to professional training. These are lacking in Nigeria. However, greater diversity must not carry with it lowered standards. African studies, commerce, teaching, engineering, medicine, agriculture, law and extra-mural studies are fields of study which are vitally important.

The most obvious need for innovation in Nigerian universities is in African studies. It must be a first duty to foster study of African history, languages, and societies, and when a sufficient body of knowledge has been built up these could be incorporated into undergraduate courses.

In Britain, most accountants, bankers, company secretaries, insurance managers and transport executives are trained 'on the job'. In America, professionals in these fields are college-trained and have degrees. An amalgamation of these two methods would suit Nigeria's needs: to offer degree courses in commerce and business administration, preferably to be taken as sandwich courses, where the student would alternate some months of office work with some months of study.

Nigeria will need 800 graduate teachers a year. Only a minority of these teachers will require a concentrated training in a narrow field, for sixth-form teaching. For the great majority, a degree based on a general curriculum would be more useful. The Commission proposes that all Nigerian universities should institute a degree of B.A. (Education). The course would take three years, and would consist of four subjects in the first year, three in the second, and three in the third year. Teaching practice and a course in pedagogy would also be included.

For many years to come Nigerian specialists in engineering will seek postgraduate experience overseas, but for her indigenous engineering training the country needs degree courses with an emphasis on the practical side, and not over-sophisticated.



# a ready supply of cold

for temperatures down to minus 200°C

Air liquefaction (33 litres per hour) - Liquid nitrogen production - Recovery of liquefied gases - Gas purification - Gas separation - Air separation - Pre-cooling - Environmental testing - Cryopumping and high vacuum processing - Metal treatment - Pulverization - Solid state engineering - Food processing - Biological tests - General low temperature research.

With Philips Cooling Machines cold capacities: 700 kcal/h up to 36,000 kcal/h at minus 195° C and 2000 kcal/h up to 70,000 kcal/h at minus 100° C.

Immediately available cold - Temperatures down to minus 200° C - High purity of product to be cooled ensured by complete separation of cooling system from production cycle - Suitable for both intermittent and continuous operation - No supervision; machine safeguarded against any failure - Compact, self Contained all-in-one construction of low weight-Delivered ready for installation.

**PHILIPS**

PHILIPS

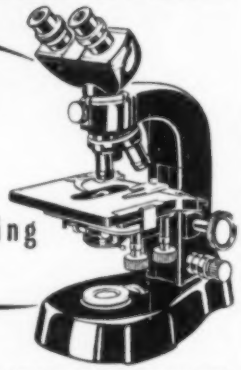
CRYOGENERATORS

N.V. PHILIPS' GLOEILAMPENFABRIEKEN - EINDHOVEN - HOLLAND

Sole distributors and advisory service for the U.K.: Research & Control Instrument House, 207/215, King's Cross Road, London WC1.

# BECK
## OPTOMAX
# MICROSCOPE

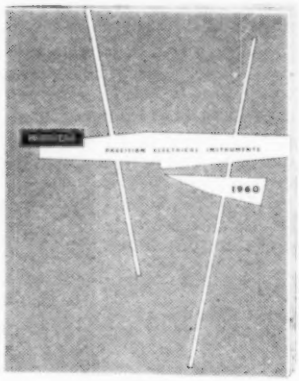
Designed for the discriminating



*Pubn. No. 251*

**R. & J. BECK LTD · 69/71 MORTIMER ST.**
**LONDON W.1**
**Pre-eminent for more than a century**

Have you had your copy?



The new MUIRHEAD abridged catalogue briefly describes the latest instruments in production and quotes the publications which describe individual types.
Send for your free issue today.

## MUIRHEAD
**PRECISION ELECTRICAL INSTRUMENTS**

MUIRHEAD & CO. LIMITED, Beckenham, Kent.
MUIRHEAD INSTRUMENTS LIMITED, Stratford, Ontario, Canada.
MUIRHEAD INSTRUMENTS INC., 441 Lexington Ave., New York 17, N.Y., U.S.A.
482

# DYNATRON
## PULSE AMPLIFIER
## type 1430A

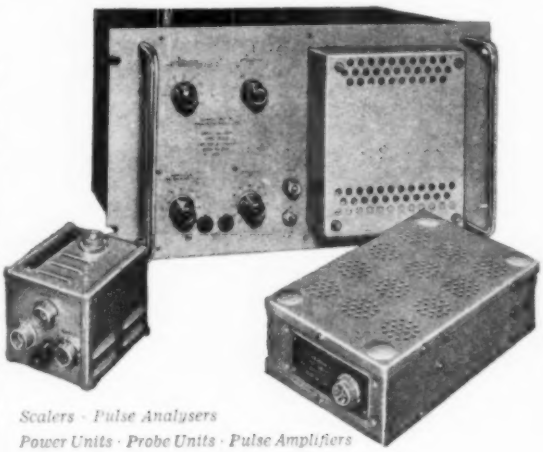
This wide band linear amplifier comprises three units, designed for use with fast ionisation chambers, proportional and scintillation counters. Write for full details of this and other Dynatron instruments.

**SPECIFICATION**

*Main Amplifier*
Input: 100 ohms impedance negative polarity.
Gain: Maximum 86dB.
Coarse Control: —0 to 20dB.
Fine Control: — 0 to 20dB in steps of 2dB each.
Integrating Time Constants: 0.08μs to 8.4s in 7 steps.
Differentiating Time Constants:
0.08μs to 8.4s in 7 steps plus 250μs step.
Output: Positive 50V for 1% linearity. Saturation 75V.
Upper Frequency Response: { 1.25dB to 1.4 Mc/s. / 3.25dB to 2.8 Mc/s.

*H.F. Head Amplifier*
Input: 10 megohms, 10pF.
Output: Designed to feed into 100 ohm matched cable.
Gain: 31.5dB.
Filter: E.H.T. Filter suitable for voltages up to 3kV.

*Cathode Follower*
Input: 10 megohms, 10pF.
Output: Designed to feed into 100 ohm matched cable.
Insertion Loss: 23dB.
Filter: As in H.F. Head Amplifier.



*Scalers · Pulse Analysers*
*Power Units · Probe Units · Pulse Amplifiers*
*Instrument Racks*

**VISIT OUR STAND 29**
**at The Physical Society Exhibition,**
**Old Horticultural Hall, London, from**
**January 16th to 20th**

## DYNATRON
**NUCLEONIC AND ELECTRONIC DIVISION, MAIDENHEAD, BERKS.**
**Maidenhead 5150 (10 lines)**

The needs of Nigeria for medical services are totally different from those of Britain. It is unreasonable to assume that the standards of attainment for Nigerians practising in Nigeria must be the same as those of Englishmen practising in England. Also, in Nigeria to-day there is one doctor to every 40,000 people (as compared with a ratio of 1 : 1,000 in Britain) so that there is a tremendous need to increase the output of doctors. Specifically, the Commission makes three main recommendations; (*a*) doubling the output of the University College Hospital, Ibadan; (*b*) instituting a locally recognized examination, for those who fail to qualify for the medical degree at Ibadan; (*c*) re-orientating the medical courses to emphasize public health, preventive medicine and paediatrics.

The Commission was favourably impressed with the state of agricultural (degree) courses at the University College, Ibadan; but the flow of graduates (20 a year) is pitifully inadequate to meet the nation's need of 200 a year.

So far as the siting of new universities is concerned, the Commission proposes that there should be four large universities, one in each of the three Regions and one in Lagos, the federal capital, rather than a number of smaller universities. These universities should be independent of one another; they should be national institutions with all three Regions equally represented on their governing bodies; and they should be financed largely from federal funds on the advice of a national universities commission.

It is recommended that the three regional branches of the Nigerian College of Arts, Science and Technology should become centres of university education. The Ibadan branch would be joined to the adjacent University College, Ibadan. The branch at Enugu, in the Eastern Region, would become part of the new University of Nigeria, at Nsukka. It would be used to develop departments of engineering, metallurgy, surveying and the social sciences, and also be the headquarters of an institute of education. The Zaria branch of the Nigerian College would become the centre of a university in the Northern Region, which would also embrace the Ahmadu Bello College of Arabic Studies, at Kano, and the Veterinary Research Institute at Vom. A particular proposal about this new university in the Northern Region is that opportunity should be given for undergraduates to read combinations of subjects drawn from different disciplines.

The University at Lagos would be an unusual type of institution, which would be non-residential, and would have three main departments. These would be a School of Commerce and Business Administration, offering both day and evening courses, a School of Economics and Social Studies, and a Department for Correspondence Courses. Although this would offer only a limited range of courses, it is believed that it would encourage large numbers of men and women, who would otherwise not have the opportunity, to improve their education and fit them for more responsible posts.

This is an outline of the Commission's main proposals. What it recommends is a stupendous undertaking, and will cost large sums of money. The Nigerian people will have to forgo other things they want, so that every available penny is invested in education. Even this will not be enough. In the words of the report, "Nigerian education must for a time become an international enterprise".

## VERTEBRATE LOCOMOTION

A SYMPOSIUM on "Vertebrate Locomotion", the fifth in the series sponsored by the Zoological Society of London, was held at the rooms of the Society on Wednesday, November 9, 1960.

Sir James Gray opened the meeting with a paper on the general principles involved in studying the mechanics of vertebrate movement. He stressed the difficulty of providing an exact treatment of the problems of aquatic and aerial locomotion and gave examples from his own work and that of his students on these and on the more amenable problems of tetrapod movement. Here, exact measurement of forces exerted by the limbs on the substratum provided a basis for analysing the locomotor system; from these results it was demonstrated that the muscular system must be treated as a single integrated whole.

Dr. R. Bainbridge, after enumerating and commenting on the many still unsolved problems in fish locomotion, concentrated on one of these—the relationship of power output, in terms of known data for muscle, to drag, calculated on various simple assumptions.

He showed that within the wide range of experimentally established estimates for the power output of different vertebrate and invertebrate muscles, it was possible to account for the observed steady speeds of progression of most small fish as well as of whales and dolphins without the need to assume completely laminar flow over the body surface. A surprising exception was provided by the barracuda.

Dr. G. M. Jarman contributed a brief note on the form of intermuscular bones and myocommata in the fish myotome. He suggested that the conical surface of a myocomma is inclined at such an angle to the longitudinal (contractile) axis of the muscle that the connective tissue mass does not change in area or thickness and therefore waste the contractile effort of the muscle.

Mr. E. H. Watts gave an account of some experiments in designing ships on lines which imitated certain features in fast-swimming fish. Perhaps the most significant of these practical exercises was the provision of lateral keels on either side of the stern, similar to those found in scombroid fishes and certain sharks. These structures slightly increased the propulsive efficiency and greatly reduced the minimum turning circle of the vessel. A more surprising result, which did not appear explicable on the models of fish locomotion described earlier by Dr. Bainbridge, was that the artificial creation of turbulent flow along the hull form appeared in some ships actually to increase the propulsive efficiency by reducing the drag.

The considerable variation in form and flexibility of the sacro-iliac joint in the anuran amphibian was described by Dr. H. P. Whiting. In *Xenopus* and

*Discoglossus* respectively, longitudinal sliding and horizontal rotation of the pelvis on the vertebral column are very marked; *Rana* shows the more commonly known rotation in a vertical plane. The different motions are consistent with observed differences in body movement of the normal animals, and suggest that an important shock-absorbing property, as well as a possible locomotory contribution, is provided by the musculature of the sacro-iliac joint.

Dr. K. M. Backhouse described the fish-like lateral motion of the hind feet of the seal when swimming in water; and contrasted this with the movement on land, where progression is achieved by dorso-ventral flexion of the trunk coupled with a hitching action of the fore limbs. Slow-motion films illustrated the terrestrial locomotion, in which the highly flexible metacarpophalangeal and interphalangeal joints of the fore limb play an important part.

Prof. E. J. Slijper, of Amsterdam, gave an account, also illustrated by film, of locomotion and locomotory organs in whales and dolphins. An interesting point to which he directed attention was the fact that cruising speed and maximum speed of the small dolphins was about the same as that for the much larger whales. He suggested that this could be explained partly by the better mechanical organization of musculature in dolphins, but also on the assumption that the flow of water over the body surface of the dolphin was almost wholly laminar, while it was partly turbulent in whales.

The power of the flying bird was discussed by Dr. R. H. J. Brown. He surveyed the various attempts to estimate this from the earliest date of Lilienthal to the more recent figures based on wind-tunnel tests, oxygen consumption figures and gliding parameters of birds in actual flight. These data suggest that the aerodynamic efficiency and the muscle-power must be very high even in normal sustained flight; greatly increased power must be available for take-off and climbing.

Terrestrial locomotion of dogs and horses was dealt with by Prof. C. W. Ottaway, who described the highly co-ordinated and integrated action of limb and shoulder muscles in the normal walking stride, and illustrated the value of nerve section and tenotomy as a method of studying the role of individual muscles.

Finally, a contribution on arboreal mammals by Dr. J. R. Napier reviewed the evolution of prehensility in the primate hand. The inward turning of the thumb which characterized true opposability required a deep carpal tunnel brought about by the set of trapezium and scaphoid, together with the existence of a saddle joint at the carpo-metacarpal articulation. True opposability is only attained in Old World monkeys, and was evolved fairly late in primate history.

The symposium was well attended, and the discussion which followed each session, though necessarily brief, raised a number of interesting points made from personal observation on locomotory behaviour as well as on the theoretical principles involved. It was fittingly concluded by the showing of a film, still in its partially edited condition, from the Zoological Society's television unit, demonstrating various modes of running and jumping by man and by animals from the collection. The slow-motion sequences collected together in the film, which was introduced by Dr. Fay Hall, were particularly interesting and instructive. John E. Harris

# OBITUARIES

## Prof. W. J. Duncan, C.B.E., F.R.S.

William Jolly Duncan, Mechan professor of aeronautics and fluid mechanics in the University of Glasgow, died on December 9 at the age of sixty-six. He had a very varied experience. Born on April 26, 1894, he was the son of Robert Duncan, M.P., senior partner of Ross and Duncan, engineers, of Glasgow. He was educated at Dulwich College and the University of London. He served in both World Wars, during the First in France and Flanders and later at the Aircraft Inspection Directorate. In the Second World War he worked for a time at the Royal Aircraft Establishment, and then as head of the Air Defence Research Establishment at Exeter. In 1945 he was sent to the Luftfahrtforschungsanstalt Hermann Göring, at Völkenrode, to supervise the disposal of German aeronautical equipment. He married in 1936 the daughter of G. S. Baker, who was then superintendent of the William Froude Ship Tank at the National Physical Laboratory, and had a family of four—all girls.

Duncan was appointed to the scientific staff of the Aerodynamics Division, National Physical Laboratory in 1926, and it was there that I, superintendent of the Division, first came to know him. In his work there, he was closely associated with the late Dr. R. A. Frazer, and A. R. Collar, now professor of aeronautical engineering in the University of Bristol. This team of three scientists was entrusted with the investigation of the new problem of aircraft flutter, a problem they were able to solve fairly completely, and in particular to lay down design rules whereby flutter could be avoided. In the process they greatly developed the theory of matrices, and together wrote a book, "Elementary Matrices", published in 1938, which has been reprinted four times and is a standard work on the subject. In 1934 Duncan left the National Physical Laboratory to become the first head of the Department of Aeronautics at Hull, and in 1938 he was made the first Wakefield professor there.

At the end of the War a group of four was entrusted with the search for a suitable site for the proposed new College of Aeronautics; Duncan and I were two of these, and we both became very interested in this revolutionary new idea in postgraduate training. When the College was eventually established at Cranfield, I became its first principal and Duncan was appointed professor of aerodynamics, and became also deputy principal three years later. I can say with certainty that the major part in the formulation of the teaching methods to be adopted in the new College was due to Duncan. It was during this period that he and I made arrangements with the Cambridge University Press for a series of aeronautical books, and Duncan's work on "Control and Stability of Aircraft" was the first of this series. Incidentally,

he also wrote the first report of the College of Aeronautics to be issued.

Duncan's teaching at the College was outstanding in excellence, as is witnessed by the fact that many of his students who specialized in aerodynamics now occupy major positions in the aircraft industry and in aeronautical research. He left Cranfield in 1950 to become the first Mechan professor of aeronautics and fluid mechanics in the University of Glasgow, a post which he held until the end of his life. He had been chairman of the Aeronautical Research Council since 1957, and was very active not only on the Council but also on many of its committees and sub-committees.

Prof. Duncan was an able mathematician and a first-class engineer, painstaking and thorough in all his work, and a great inspiration to those who had the good fortune to work with him. He was elected a Fellow of the Royal Society in 1947 and was appointed C.B.E. in 1953. His publications, besides the two books already mentioned, include one on "Physical Similarity and Dimensional Analysis", together with numerous reports and papers published in the Reports and Memoranda of the Aeronautical Research Council, the *Proceedings of the Royal Society*, and the *Philosophical Magazine*. His death will be felt as a great loss by his many friends and collaborators, and by the world of mechanical engineering in general.

ERNEST F. RELF

## Prof. J. G. Andersson

PROF. JOHAN GUNNAR ANDERSSON, formerly director of the East-Asiatic Collections at Stockholm, was one of the Swedes who have made lasting contributions to our knowledge about the natural resources of China and the history of the civilization of that country.

He was born on July 3, 1874, at Knista in the province of Örebro, and died in Stockholm on October 29. After studying at the University of Uppsala, he obtained there the degree of M.Sc. in 1901, became D.Sc. in 1902, and was appointed professor of geography in 1906. Already during his years as a student he devoted himself to the examination of the Silurian deposits of his native county of Närke and of Öland. These investigations resulted in a couple of palæontological communications and a study of the distribution of phosphorites in the Silurian.

As a young student he took part in several expeditions into the Arctic regions. Thus he was a member of the expedition to Spitsbergen led in 1898 by the Swedish polar explorer A. G. Nathorst. In 1899 Andersson undertook an expedition of his own to Beeren Island. The geological results of this undertaking he described in his doctoral thesis, "Über die Stratigraphie und Tektonik der Bären Insel". When in the years 1901–3 Otto Nordenskjöld undertook his famous Antarctic expedition, Andersson was second in command, and when Nordenskjöld together with some other members had established winter quarters on Snow Hill, Andersson took over the leadership of the expedition to South Georgia, the Falkland Islands, and Tierra del Fuego, and also during the second trip of the vessel to the Antarctic. Afterwards Andersson left the vessel with two companions in order to reach Nordenskjöld's winter quarters by land. Before reaching it he was, however, forced to spend a winter under very trying conditions. He then joined Nordenskjöld's group in the following spring. In the meantime, their ship foundered in the pack-ice, yet without loss of human lives. This expedition and its rescue by an expedition sent out from Argentina forms one of the more thrilling chapters in the history of the exploration of the polar regions.

In 1906 Andersson was made head of the Geological Survey of Sweden. After having had leave of absence since 1914, he left this post in 1916. During his comparatively short time as head of this organization, he introduced a number of new and important investigations into its programme. This applies first of all to the production of oil and radium from the oil-shales. The organization of the Geological Survey as established in 1914, which has remained in force to the present day, is to a large extent due to him. During the Eleventh International Geological Congress, held at Stockholm in 1910, he was, partly in collaboration with H. Munthe and A. Gavelin, the editor of the publications of the Congress.

As mentioned already, Andersson had obtained leave of absence in 1914 from his post as head of the Geological Survey, and had entered the service of the Chinese Government as mining adviser and organizer of the geological exploration of the ore and mineral resources of China. It was during this period that he became widely known as an explorer of China. In addition to the study of ore geology, he found time for extensive studies of the fossil faunas and floras of China as well as for remarkable archæological excavations that threw light on the earliest settlement of China. In his endeavours he enjoyed powerful support from the Chinese Government and from the Swedish Parliament. From this field of activity 'China Gunnar', as he was called in many circles, brought back extensive collections which are now in different Swedish museums.

After his return from China, Andersson was appointed in 1926 to a chair of geology in the University of Stockholm. From this he retired, however, in the following year, in order to devote himself to the arrangement of his collections, and to a new trip to China. On his return from his second visit to China he was made director of the East-Asiatic Collections in Stockholm, and was given a personal chair in East-Asiatic archæology which he then occupied until 1939.

Andersson published the results of his researches and explorations in a great number of scientific papers. His studies in the Far East were summarized in his "Topografisk-arkeologiska studier i Fjärran Östern" (1939). He had a great gift of popularizing his knowledge, both as a lecturer and as an author. In 1926 he published his account of China, "Draken och de främmande djävlarna", followed by "Den gula jordens barn" (1932), the autobiographical "Kineser och pingviner" (1933), and "Under brinnande krig" (1938). He surveyed his own life and his life's philosophy in a book, "Mitt liv och min tro" (1956).

ERIK ÅHMAN

## Dr. Louis Clarke

LOUIS CLARKE'S death on December 13 leaves a gap in the hearts of his innumerable friends, for he was a much-loved man. He was wealthy and was blessed with intelligence and common sense, with a lively understanding of human nature and with the standards of behaviour of his Christian Victorian upbringing. He travelled widely after leaving Cambridge, especially in South America and

Abyssinia, and was extremely knowledgeable in matters of archæology and art. Hence his two official jobs, first as curator of the Museum of Archæology and Ethnology at Cambridge, and later as director of the Fitzwilliam Museum.

But the outstanding fact was that Louis could neither be described as an academic nor as an ordinary person. He took a very modest degree, and, though in later life his eminence was such that his University gave him an honorary doctorate, he was essentially an example of the fine fruit of what England so specially has produced in the past: he was a distinguished amateur. This is high praise, and it was only possible because in his early life his intellectual energies had not been canalized into a narrow channel: he had had opportunity and leisure to cultivate wide interests and friendships and to gain a broad, wise outlook on life. His knowledge became encyclopædic: he could give you the provenance of any object you might offer for his inspection! Those who knew him well will never forget his enormous, cheery voice resounding through the two Museums he successively controlled, nor his capacity, possibly unrecognized by himself, to unite any team with which he worked into a whole.

At the Museum of Archæology and Ethnology, where he followed Baron von Hügel and Dr. A. C. Haddon and where much had been done to build up a new Museum, it was nevertheless under his direction that it became what it is to-day. He was extremely generous, too, in his gifts to the collections, and much more generous than people knew throughout his life to young or struggling archæologists, financing 'digs' in out-of-the-way parts of the world and adding the results of their excavations to the Museum collections. At the Fitzwilliam his influence was at first to some extent crippled by the War and all that world upheaval meant to a great art museum, but afterwards he was able to do much to further the objects of that universally known institution.

But facts give no picture of the man, with his kindly humour and tremendous knowledge of people, a knowledge which began in his own family of thirteen brothers and sisters and extended to include savants from all over the world. Above all, there was nothing ungenerous in his whole make up, and he has been an ornament to the Cambridge of his generation. For some years his heart had given him trouble, and he died quietly in Cambridge in his eightieth year on December 13.

M. C. Burkitt

# NEWS and VIEWS

## Geological Society of London: Awards

The Council of the Geological Society of London has made the following awards for 1961: *Wollaston Medal*, to Prof. Roman Kozlowski, emeritus professor of palæontology, University of Warsaw, in recognition of his distinguished contributions to palæozoology, especially to knowledge of the graptolites; *Murchison Medal*, to Mr. W. N. Edwards, assistant director, Geological Survey of Great Britain (Leeds), for his contributions to the stratigraphy and structure of the Coal Measures, particularly in the Yorkshire–Nottinghamshire Coalfield; *Lyell Medal*, to Dr. J. V. Harrison, lately reader in structural geology, University of Oxford, for his contributions to structural geology and his pioneer work in remote countries; *Bigsby Medal*, to Prof. Alwyn Williams, professor of geology, Queen's University, Belfast, in recognition of his work on the Lower Palæozoic stratigraphy, palæontology and structural geology; *Wollaston Fund*, to Dr. E. A. Vincent, reader in mineralogy, University of Oxford, for his work on the iron–titanium minerals and on geochemistry; *Murchison Fund*, to Dr. J. Ineson, district geologist (Water Department), Geological Survey and Museum, London, for his fundamental contributions to the investigation of ground-water resources in Britain; a moiety of the *Lyell Fund* to Dr. R. G. West, demonstrator, Department of Botany, University of Cambridge, for his contributions to the geology and palæobotany of the Pleistocene of the British Isles; another moiety of the *Lyell Fund* to Dr. W. T. Dean, Department of Palæontology, British Museum (Natural History), London, for his work on the stratigraphy and palæontology of the Middle and Upper Ordovician in Great Britain.

## Royal Society and Nuffield Foundation Commonwealth Bursaries

Awards under the Royal Society and Nuffield Foundation Commonwealth Bursaries Scheme have been made as follows: Mr. J. Attridge, lecturer in zoology, Birkbeck College, to assist him in doing further work on the Dinosaur beds, and other fossil reptile deposits, of the Karroo System in Southern Rhodesia, from June to October 1961; Dr. M. M. Chakrabarty, reader in applied chemistry, University of Calcutta, to assist him in studying new techniques for the investigation of fatty oils at the Prairie Regional Laboratory, Saskatoon (and possibly also at the Paint Research Station, Teddington), for about six months from March 1961; Prof. J. H. O. Day, professor of zoology, University of Cape Town, to enable him, for about nine months from February 1961, to study type specimens at the British Museum (Natural History) in connexion with the preparation of a monograph on the South African Polychaeta; Dr. W. H. Elliott, Biochemistry Department, John Curtin School of Medical Research, Australian National University, Canberra, to assist him in visiting Cambridge for about a year from September 1961 in order to study microbiological techniques; Dr. D. E. Hoare, lecturer in physical chemistry, Queen's College (Dundee), University of St. Andrews, to enable him to study reactions of hydroxyl radicals with hydrocarbons at the National Research Council, Ottawa, from April to September 1961; Mr. C. R. Horrell, of the Department of Agriculture, Uganda, to enable him to visit Queensland from January to April 1961 to study the development of tropical pasture grasses and legumes for the production of temporary leys; Dr. C. A. Hurst, senior lecturer in mathematical physics, University of Adelaide, to assist him in visiting Edinburgh for about eight months from February 1961 in order to investigate the properties of relativistic two-body equations; Prof. J. C. Jaeger, professor of geophysics, Australian National University, Canberra, to enable him to carry out a study of stresses in deep mines and correlation with seismic observations, at the Bernard Price Institute, Johannesburg, for about three months

from November 1961; Mr. I. C. McKellar, of the New Zealand Geological Survey, to assist him in studying glacial geology, Pleistocene stratigraphy and techniques in glaciology in British Columbia, during April and May 1961; Dr. S. S. Qadri, reader in zoology, University College of Science, Osmania University, to enable him to learn protozoological techniques at the London School of Hygiene and Tropical Medicine for a year from January 1961.

## Electrical Research Association: New Appointments: Dr. R. H. Golde

Following the retirement of Mr. H. M. Lacey on September 30, Dr. R. H. Golde was appointed head of the Surges and Transformer Department of the Electrical Research Association. Dr. Golde is secretary of the Study Committee on Lightning and Surges of the Conférence Internationale des grands réseaux électriques, a member of the International Committee on Lightning Protection and of several British Standards Institution, Institution of Electrical Engineers and International Electrotechnical Commission committees. He was educated at the Technical University of Berlin. He joined the Electrical Research Association in 1935 and took his Ph.D. degree at Queen Mary College, London, and has been awarded the D.Sc. (Eng.) by the same University.

## Mr. M. Waters

Mr. M. Waters has been appointed deputy head of the Surges and Transformer Department. Mr. Waters received his early training with A. Reyrolle and Co., Ltd., and during his apprenticeship there he won the scholarship of the North East Coast Institution of Engineers and Shipbuilders, which enabled him to proceed to King's College, Newcastle upon Tyne, where he graduated with honours in electrical engineering. Mr. Waters returned to Reyrolle's, working in the Research Department. After gaining experience in power station construction with Parolle Electrical Plant Co., Ltd., he joined the Electrical Research Association in 1946 to undertake research on power transformers.

Mr. L. Gosland has been appointed deputy director of the Electrical Research Association. This appointment is additional to his position of research manager, which he will continue to hold. Mr. C. G. Garton and Mr. E. W. Golding are appointed assistant directors of the Association. Mr. Garton will continue as head of the Materials Department, and Mr. Golding will continue as head of the Rural Electrification Department, and also as overseas liaison officer.

## The British Association for the Advancement of Science: Norwich Meeting

The annual meeting of the British Association for the Advancement of Science for 1961 is to be held at Norwich during August 30–September 6. This will be the third time that the meeting has been held at Norwich, the previous occasions being during 1868 and 1935, and again it promises a programme with a strong East Anglian interest. Concurrently with the main meeting will be a series of four illustrated lectures for young people, who will themselves organize an exhibition designed to illustrate the scientific work being carried out in the Norwich and county schools. Appointments to the three special lectures are as follows: Kelvin Lecture, Prof. D. J. E. Ingram, professor of physics, University College of North Staffordshire, on investigations in the microwave region of the electromagnetic spectrum; Darwin Lecture, Dr. Judith Milledge, lecturer in crystallography, University College, London, possibly on the importance of borderline subjects—with special reference to crystallography; Lister Lecture, Dr. R. G. Lipsey, reader in economics, University of London, on a subject connected with theory and observation in economics. In addition to the programme for young people at Norwich, Junior British Association meetings will be arranged in 1961 in the West Midlands, Cornwall, Sheffield and Tees-side. The first of a new venture—"Science Fairs"—will be organized in Manchester during March (in collaboration with the Manchester Federation of Scientific Societies), in Tees-side during December and at Newcastle upon Tyne at Easter 1962. Further information concerning the activities of the Association can be obtained from the British Association for the Advancement of Science, 18 Adam Street, Adelphi, London, W.C.2.

## Theology and the Sciences at Birmingham

The University of Birmingham is undertaking a development in its Department of Theology of more than ordinary interest. A second chair, provided by the Edward Cadbury Trust, has been established for a period of seven years in the first instance. This chair will be filled by someone whose interests stretch across the borders between the natural sciences, philosophy and theology. It is hoped that the new professor will pioneer research and teaching in this general area. In Birmingham the sciences have always been strongly represented, and, at present, half the students in the University are reading for degrees in the Faculty of Science. Moreover, last October the Faculties of Arts and Law moved to Edgbaston, and, for the first time for nearly sixty years, all the departments of the University were gathered in a single place. This development seemed to offer an opportunity for interesting and profitable work in exploring the little-known territories where theology, the natural sciences and philosophy meet. The Department of Theology itself, now twenty years old and growing steadily, is non-denominational and widely representative.

## Statistical Review of England and Wales for 1958

The Registrar General for England and Wales has recently issued the third part of his "Statistical Review for 1958", containing the commentary on the vital events of that year (Pp. xiv + 222. London: H.M. Stationery Office, 1960. 13*s.* net). In this volume, which appears after the medical and civil tables, the official statisticians take a careful look at the figures and discuss the implications and trends of vital rates. During 1958, the home population rose by 199,000, of which 185,000 was natural increase (excess of births over deaths), and 14,000 the balance of migration, which it must be remembered includes migration from Scotland and Ireland. It is estimated that there was a net loss of 5,000 on overseas migration, and a net gain of 19,000 on migration within the United Kingdom. Marriage-rates continued to be high, and a continuation of 1958 nuptiality would imply that only 5 per cent of the population would have remained single at age 50, a lower proportion than any ever actually recorded. The number of unmarried men aged 17½–45 exceeded that of unmarried women aged 15–42½ by 6 per cent; only seven years earlier in 1951 this figure had shown a 3 per cent deficiency. On the reverse side, new divorce petitions continued to decline in number;

the 26,000 petitions filed in 1958 were the lowest number recorded since the end of the Second World War. The number of live births was 741,000, the highest figure since 1948. One-eighth of these births were conceived outside marriage, but 60 per cent of these were legitimized by the parents marrying before the birth of the child. It was still, however, premature to say whether this number indicated an increase in total family size, or merely a temporary change in the timing of births within marriage, though it was clear that the rates implied that the population was replacing itself with a margin to spare. In the extensive analysis of mortality, there is a comment on the gap between male and female death-rates. The male rate is now more than double the female in two age groups: 15–24, where men have much higher death-rates from accidents, and at ages 55–64, where the principal contributions are made by coronary disease, with a male rate 3·6 times that of the female, cancer of the lung (9·7) and bronchitis (5·2). There is the usual extensive discussion of cause of mortality. The volume contains a special note on deaths following vaccination and other prophylactic inoculations, and on deaths following from therapeutic misadventure.

## Euratom Translation Office at Brussels

The European Atomic Energy Community (Euratom), the United Kingdom Atomic Energy Authority and the United States Atomic Energy Commission have agreed to pool their efforts to collect and disseminate information concerning translations of nuclear literature, especially from such languages unfamiliar to Western readers as Russian and Japanese. A central information office, called 'Transatom', has therefore been established at Euratom's Brussels headquarters. The office publishes a monthly *Transatom Bulletin*, which lists existing translations recently reported to the Brussels office as well as new translations planned by international or national institutions and private firms in the European Community, the United States, the United Kingdom and in other countries. All data relating to translations, including those made before the establishment of Transatom, are being collected and recorded in a master file system at Brussels. Copies of this card file have been offered to appropriate institutions in countries with great interest in the nuclear field. Contacts have been established in order to avoid duplication of work when the European translation centre, to be established at Delft, Holland, is set up. The scope of this institution is much wider: it will cover all scientific and technical material in the field of exact sciences. The *Bulletin* is available on a subscription basis from Transatom, 51 Rue Belliard, Brussels, at 8 dollars per annum, or 16 dollars air mail.

## Use of Film in Scientific Research

The Department of Scientific and Industrial Research has set up a working party to consider national needs in the field of scientific film. It is especially interested in the aspects of film as a research tool and in communicating research results. To assist the working party the Department, in co-operation with the other research councils, the Atomic Energy Authority and some Government Departments, is circulating a questionnaire to industry, universities and research organizations. The working party consists of: Dr. W. L. Francis (chairman); Mr. Edgar Anstey, British Transport Commission, president of the Scientific Film Association; Mr. D. E. H. Densham, Ministry of Aviation; Sir Arthur Elton, Associated Electrical Industries; Mr. C. Engel, Medical Illustration Department, Guy's Hospital; Prof. G. E. H. Foxon, Guy's Hospital, president, British Universities Film Council; Mr. L. E. Hallett, Royal Photographic Society of Great Britain; Prof. C. H. Waddington, Institute of Animal Genetics, Edinburgh. Three members of the Department of Scientific and Industrial Research are also included: Mr. H. E. Beckett; Mr. L. Poole; and Mr. R. E. Overbury (secretary). Further information can be obtained from the Information Division, Department of Scientific and Industrial Research, 14–18 Cornwall Terrace, London, N.W.1.

## British Catalogue of Films for Universities

To assist the university teacher, who may have difficulty in locating films available for teaching purposes, the British Universities Film Council has issued a catalogue of some 1,400 titles classified according to the Universal Decimal Classification, together with an alphabetical index of titles (Pp. 166. Glasgow: British Universities Film Council, Royal College of Science and Technology, 1960). Besides a list of distributors there is appended a list of subject catalogues. The Catalogue has hitherto been issued as a card index, usually placed in the university library, but it is intended to reprint it in four or five years time. It is hoped that issue in book form, by widening its distribution, for example, so as to permit copies to be available in departments, will both stimulate the use of films in universities and comparable institutions and engender interest in expanding the catalogue. Suggestions as to films which might be included in future supplements are invited. Issue of the Catalogue in separate parts is contemplated and this should be an advantage to many users, particularly with further expansion of the Catalogue.

## New British Oceanographic Research Ship

Plans for a new research ship to replace R.R.S. *Discovery II*—now 31 years old—are almost complete, and it is hoped shortly to invite tenders for her construction by the early summer of 1962. The great advances in oceanography in the past decade have shown that there is a real need for a comprehensive research ship capable of working in any ocean, and in almost any weather. The demands for laboratory and ancillary spaces, together with present-day requirements for crew accommodation, alone necessitate a ship larger than *Discovery II*, and, as the life of a research ship may well be 25–30 years, allowance must also be made for future needs. The suggested design envisages a ship with an overall length of 260 ft., a beam of 44 ft. and a displacement of about 2,800 tons. Laboratory and other scientific spaces will occupy some 3,000 sq. ft. and will provide facilities for marine physics, biology, chemistry, geology, geophysics and meteorology. Diesel-electric drive, with a single screw, will allow a service speed of 10 knots and a range of about 15,000 miles. Special attention is being paid to the provision of adequate supplies of electric power, not only now but also in the future. Deck machinery will include separate winches for coring, trawling and all normal oceanographical work. Other special features are the bow propulsion unit, for giving sideways thrust, and an open trunk through the centre of the ship through which experimental apparatus can be lowered.

## Postgraduate Education for General Practitioners

A RIDDLE which puzzles all those concerned with the maintenance of standards of general practice is why more than 70 per cent of the general practitioners in England and Wales undertake no form of post-graduate education. Some general practitioners feel that they can keep up to date by their contacts with fellow-practitioners or consultants or by reading. Others think that the postgraduate courses offered to them are not satisfactory. There are many, however, whose reasons for avoiding postgraduate courses are far from clear, and, to help them, a conference was arranged by the British Postgraduate Medical Federation and the Metropolitan and Home Counties Faculties of the College of General Practitioners. The eight opening papers of the conference have now been published in a recent issue of *The Practitioner* (185, No. 1109; November 1960). With the exception of Dr. H. G. McGregor, who is adviser on postgraduate education to the South-eastern Metropolitan Hospital Region, the contributors are all general practitioners. The papers represent an authoritative review of what general practitioners feel they require if postgraduate courses are to be of real value. A general conclusion is that the formal lecture should now have little place in the education of the general practitioner, who should play an active part in all postgraduate courses.

## History of Science in Poland

IN December 1958, a plenary meeting of the History of Science Committee of the Polish Academy of Sciences decided that a concise outline of the history of science in Poland should be prepared. In character and level, it is to be a university text-book, emphasizing general aspects of science, conditions of development, organization of scientific work, and the trends in scientific thought which are common to various disciplines. Specific sections will be devoted to the development of various branches of science and the more eminent personalities and their work in Poland. The sections devoted to specialized subjects in particular periods are to be as succinct as practicable, and to embody the maximum possible volume of information. A tentative plan is discussed in the January–March issue of *The Review of the Polish Academy of Sciences* (5, No. 1 (17); 1960).

## Salvage: Waste or Wealth

ALTHOUGH it is well known that one industry's waste may be the raw material for another, it is equally well recognized that many firms have found themselves in difficulties because their waste costs have been too high and because they have been unable to make a saleable commodity from their wastes. In the first of a new series designed to be of practical use to industrial management, the Department of Scientific and Industrial Research has produced a booklet which, properly used, could mean the difference between success and failure for many struggling organizations. The booklet, "Waste or Wealth," by Clement Brown, is a collection of stories which show how, by research or technical aid, many industrial wastes are being turned to profit (Pp. 27. London: H.M. Stationery Office, 1960). There are still serious cases of unclaimed wastes—several million gallons of paint are lost each year during spraying; little attempt is being made to make use of scrap leather and a fresh application is needed; a new use for sugar, now produced in excess of demand, is being investigated and could form the basis of a detergent. The booklet's stories of success should spur the inventiveness of management. It may be obtained free of charge from the Department of Scientific and Industrial Research Lending Library Unit, 20 Chester Terrace, London, N.W.1. Readers will wish to commend the Department for the earthy and practical way in which the booklet has been presented and for choosing Peter Knebone to add those humorous illustrations which tell vivid stories without words.

## The British Society for International Understanding

THE annual report for 1960 of the British Society for International Understanding, presented to the twenty-first annual general meeting on November 16, 1960, notes that the Society has now published some 600 British Survey pamphlets (Pp. 10. London: The British Society for International Understanding, 1960). These pamphlets have been written by experts and each is devoted to the distinct characteristics of a single Commonwealth or foreign country or to some well-defined international topic. Much of the energies of the staff is now directed to building up and maintaining the Atlantic Treaty Organization and its United Kingdom branch, the British Atlantic Committee. Lord Bessborough, the chairman of the governing body, has suggested that the time has come to give the same special attention to the cultivation of good relations and mutual understanding between Britain and the emergent nations of Africa. The report includes details of publications during the year and of the activities of both the Atlantic Treaty Association and the British Atlantic Committee.

## Aeronautical Research in Australia

THE annual report for 1958–59 of the Aeronautical Research Laboratories of the Australian Defence Scientific Service has recently become available (Pp. 39. Melbourne: Department of Supply, Aeronautical Research Laboratories, 1960). The report is a well-illustrated booklet of thirty-nine quarto pages which record recent progress in research and development, and is refreshingly devoid of 'propaganda'. The research undertaken is relevant either to Australian and Commonwealth defence, or to Australian industry and national development. It is distributed between the various divisions, aerodynamics, structures, materials and mechanical engineering, and covers a very wide range of problems. Since guided weapons are finding wider and wider application and since Woomera, the Commonwealth test-range, is at hand, there is great emphasis on missiles and missile propulsion. A co-ordinated team specializing in this field is suggested. Nevertheless, there is much that concerns current military and civil aircraft. Some interesting work on the fatigue life of aircraft structures is reported—including an investigation aimed at providing a method for the experimental verification of the 'fail-safe structure' so often claimed by designers. There is also the work of the human engineering group on the piloting problems during landing. In an appendix are listed 44 reports and notes dealing with major research projects and the 36 technical memoranda on minor and *ad hoc* investigations. Altogether an interesting year's work.

## Rock Carvings in Central Australia

THE October issue of *Man* contains an interesting article recording some simple rock carvings at

Ewaninga in Central Australia by C. P. Mountford, who has done so much work on this subject. The carvings are made by a pocking technique and consist of rough drawings of stylized figures and signs, consisting of spirals, circles, arrows, etc. The local native inhabitants apparently know nothing about them, and indeed frequently had not realized that they were the works of man. Rock carvings do not occur everywhere in Australia. They have not been found along the southern and south-eastern coasts, but have been found in Tasmania. In Central Australia they have been known for a long time; Mountford records that Miss Helen Teague gave him some photographs of carvings near Glen Helen as long ago as 1937. The signs are very varied in type, but are, of course, nowadays inexplicable.

## Fertility of Ewes

Margaret Ryle, of the Department of Physiology, University of Queensland, has investigated the relationship between high temperature and vitamin A metabolism and the fertility of ewes (*Austral. J. Science*, 23, No. 2; August 21, 1960). The gross effects of vitamin A deficiency have much in common with those of high environmental temperatures. Partial inhibition of follicle development and of œstrus have been reported as a result of vitamin A deficiency in rats and rabbits and of high temperature in rats. Some of the available data on sheep suggest a similar vitamin A effect: the adverse consequences of high temperatures on conception-rate in sheep are reported by several authors. Increased embryonic mortality is described in rats, rabbits and sheep as a result both of vitamin A deficiency and high environmental temperatures. Vitamin supplements have been shown to reduce fœtal resorptions in heat-treated rats. Failure of normal development of the maternal uterine epithelium as the immediate cause of fœtal mortality is indicated both in vitamin A deficient rats and in heat-exposed rabbits. Changes have been described in the pituitary and thyroid glands both of vitamin A deficient animals and of animals exposed to high temperatures, but strictly comparable studies are required to determine whether or not they are of the same nature. In general, only further experimental work can decide whether the similar consequences of the two types of stress are merely coincidental, or whether they have a casual connexion such as the one suggested.

## Forthcoming International Scientific and Technical Conferences

A list, No. 28, has been issued by the Department of Scientific and Industrial Research entitled *Forthcoming International Scientific and Technical Conferences*. The list, covering the period January 1961–December 1962, amends and amplifies the information contained in the previous lists on all scientific and technical conferences of an international character, held in the United Kingdom or elsewhere. The information is presented under four headings giving the subject of conferences, their dates, the convening bodies and/or organizers, and also the places where they are to be held. The subject index at the end does much to enhance the value of this publication. Copies can be obtained from the Department of Scientific and Industrial Research, Charles House, 5–11 Regent Street, London, S.W.1.

## Announcements

Sir Brian Windeyer, of the Meyerstein Institute of Radiotherapy, Middlesex Hospital, London, has been appointed chairman of the Radioactive Substances Advisory Committee in succession to Sir Charles Darwin, who has resigned.

The Ministry of Agriculture, Fisheries and Food and the War Office announce that Brigadier A. H. Dowson, director of military survey, War Office, has been appointed director general of the Ordnance Survey, with the rank of major general, in succession to Major General L. F. de Vic. Carey, C.B., C.B.E., who is retiring on June 30.

The Jones–Bateman Cup, which is offered triennially by the Royal Horticultural Society for original research in fruit growing, has been awarded to Mr. A. Gavin Brown of the John Innes Institute, Bayfordbury, Herts. for his research work on the inheritance of susceptibility to diseases in apples and pears, the inheritance of shape, size and season of ripening in apples, and other matters relating to the breeding of fruits.

Mr. P. Lloyd, deputy director of research and development at the National Gas Turbine Establishment, has been appointed director general of engine research and development in the Ministry of Aviation

The International Measurement Conference, IMEKO 1961, is to be held in Budapest during June 25–July 1, 1961, and will be accompanied by an exhibition. Further information can be obtained from the IMEKO Secretariat, Budapest, 5 (P.O. 3).

Under the sponsorship of Nato, a summer school will be organized at the University of Ghent during July 24–August 5. The subjects to be considered are the electrical, optical and mechanical properties of lattice defects. Information can be obtained from Prof. W. Dekeyser, Laboratorium voor Kristallografie en Studie van Vaste Stoffen, Rozier, 6 Ghent, Belgium.

The first international congress on "Ergonomics" is to be held in Stockholm during August 20–23, 1961; the congress is being organized by the International Ergonomics Association. The programme will include the following subjects: speed of work and ergonomics; adjustment of work and working environment to the ageing population; ergonomical job analysis. Further information can be obtained from Prof. Sven Forssman, Svenska Arbetsgivareföreningen, P.O. 16120, Stockholm 16, Sweden, or the British representative on the provisional committee, R. G. Stansfield, D.S.I.R. Warren Spring Laboratory, Gunnels Wood Road, Stevenage, Herts.

Hansom Books, Ltd., under the title "Technical Books-in-Print", list and detail all technical and scientific books available in Britain, including books due for publication. In *Physics and Mathematics* of September 1960 the titles are arranged alphabetically under: physics—general; light and sound; electricity and magnetism; heat, radiation, thermodynamics; mechanics, dynamics, quantum theory; nuclear and atom physics; physics—miscellaneous; mathematics—general; applied mathematics; algebra; geometry, trigonometry; calculus, differential equations; statistics (Vol. 1, No. 8. Edited by W. G. Smith. Pp. 60. (London: Hansom Books, Ltd., 1960.) 6*d*.). From the October issues the price of each part is increased to 9*d*. (11*s*. per annum by post). *Books in Britain* will be 3*s*. per copy, 42*s*. per annum.

# NEW BUILDINGS AT THE FIRE RESEARCH STATION

By D. I. LAWSON

Joint Fire Research Organization of the Department of Scientific and Industrial Research and Fire Offices' Committee

THE new buildings of the Fire Research Station of the Joint Fire Research Organization of the Department of Scientific and Industrial Research and the Fire Offices' Committee, which have a floor area of 30,000 sq. ft., were opened on November 4 by the Right Hon. Viscount Hailsham, Lord President of the Council and Minister for Science. This new accommodation, built at a cost of about £300,000, doubles the previous floor area and makes the Fire Research Station the largest and best-equipped organization of its kind in the world.

The scheme comprises a three-storey block (Fig. 1), 200 ft. long, 36 ft. wide and 33 ft. high, of laboratories and offices and two separate blocks of three 30-ft. high laboratories, each having a floor area of about 2,500 sq. ft., for hydraulics, thermal radiation and chemical engineering research.

A 7,500-gallon concrete storage tank is built in the floor of the hydraulics laboratory to conserve water returned from experiments. Two pumps are provided in the laboratory, one having a capacity of 1,000 gal./min. at a pressure of 121 lb./in.$^2$ and the other a capacity of 250 gal./min. at a pressure of 156 lb./in.$^2$. These are used for testing equipment submitted by manufacturers, including alarm valves and sprinkler systems.

The radiation laboratory will be used for problems relating to ignition and spread of fire, and for this purpose a 4-ft. square gas-fired radiant panel has been installed at one end of the laboratory.

Explosion hazards of combustible dusts and the self-heating of unstable chemicals will be studied in the new chemical engineering laboratory.

The opening of the new buildings came nearly fourteen years after the formation of the Joint Fire Research Organization by the Department of Scientific and Industrial Research and the Fire Offices' Committee. One of the principal older buildings houses furnaces for examining the performance of structural elements under fire conditions, the largest furnace having a maximum gas consumption of 25,000 cu. ft. per hour; indeed, the maximum total gas consumption of the Fire Research Station is sufficient for a small town.

During 1958, a large laboratory, the models laboratory, 150 ft. long, 50 ft. wide and 40 ft. high, was added to the existing buildings for the purpose of studying the modelling of fires. This has a roof which will open over 24 ft. to release smoke and hot gases. A 12-ft. diameter fan, driven by a 200-h.p. motor, can be used to draw air transversely across the laboratory at speeds up to 30 m.p.h. over a working section 15 ft. long, 15 ft. wide and 10 ft. high.

The present staff totals 136, and the scientific work of the Station is organized into five sections.

## Operational Research and Intelligence

Each year this Section receives from the Fire Service Department of the Home Office details of about 120,000 fires which have been attended by local authority fire brigades. After coding and analysing them, the Section produces annual statistical tables and notes trends in the incidence of fire, casualties and damage. Detailed studies are made of specific hazards—for example, fires caused by oil-burning appliances or by electricity. Investigations are also made into the effectiveness of equipment, such as sprinklers and fire-detectors. The work of this Section provides an essential background for planning the research programme as a whole and for the administration of fire protection.

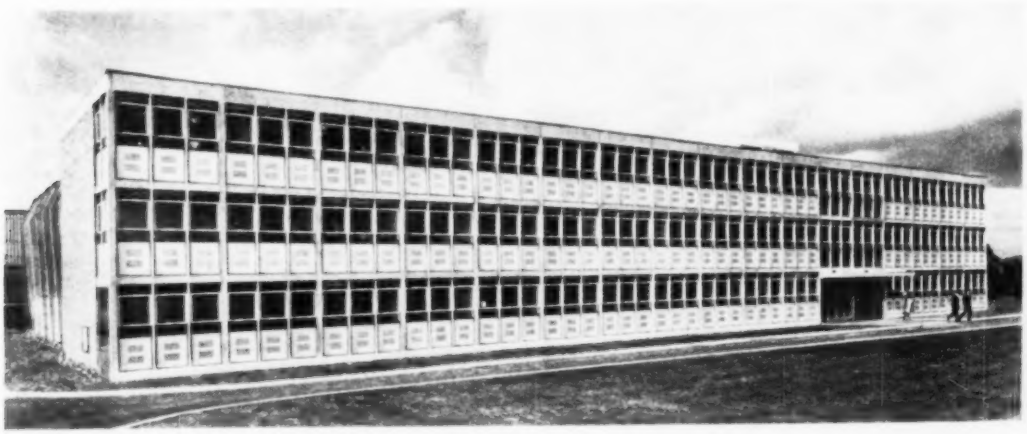


Fig. 1. The Main Building of the Fire Research Station, Boreham Wood, Herts

### Ignition and Growth of Fire

In this Section physical aspects of combustion and heat transfer are studied. Techniques involving the use of models are being developed to determine the factors—particularly wind, ventilation, fuel, and shape and size of compartment—which control the growth of fire and its spread within and between buildings. The aim of this work is to provide a scientific basis for the fire grading and adequate separation of buildings. Ten laboratories in other countries are also co-operating on an agreed programme of experiments with models. The results of this international programme should lead to theoretical understanding of the progress of fires in buildings.

Further work is being carried out on the development of fires in the open, as this will have application both to forest fires and fires in built-up areas.

### Building Materials and Structures

Since much of the total damage by fire occurs in buildings, this Section studies building materials under fire conditions to obtain basic data for the design and protection of structures which will help to control the development and spread of fire. It also performs, at the request of manufacturers, many tests on structural elements, and spread-of-flame tests on building materials. Its work is being used in the revision of building by-laws, and in the advice given to architects, builders, structural engineers and local authorities on appropriate types of structure and materials.

### Chemistry and Chemical Engineering

This Section is concerned with industrial fires and explosions involving gases, vapours, dusts and unstable materials not classified as explosives. Working in close co-operation with the Factory Inspectorate of the Ministry of Labour, its aim is to assess hazards and devise precautionary measures. In collaboration with the Extinguishing Materials and Equipment Section, studies are made of the means of extinguishing fires in flammable liquids, the use of vapour phase inhibiting agents and the possibility of extinguishing fires in buildings by filling the interior with inert gas. Experiments with inert atmospheres are now being carried out with a specially adapted jet engine.

### Extinguishing Materials and Equipment

The main purpose of this Section is to study the properties of, and methods of applying, extinguishing agents, for example, water, foam and dry powder. Models of rooms and buildings are used to learn more about the various mechanisms by which water puts out fires. This Section studies the automatic detection of fires and the performance of detection systems. It carries out tests—many of them for the Fire Offices' Committee—on equipment, including automatic sprinkler systems, portable fire-extinguishing appliances, and automatic fire alarms. In co-operation with official bodies and manufacturers, the Section assists in drawing up standards and specifications for such equipment.

In addition, the Fire Research Station has a library which provides an extensive coverage of fire literature as well as information and intelligence services.

## FUTURE OF THE GENERAL DEGREE IN BRITISH UNIVERSITIES

DISCUSSIONS at the Home Universities Conference are not required to reach agreed conclusions. Had this been the case, the discussion on the "Future of the General Degree" during the recent Conference of the Universities of the United Kingdom, held in London during December 9–10, would probably have reached the conclusion that it is a good degree, but that it may have no future.

There were two opening speeches. The first was given by Mr. D. W. Reece, lecturer in humanity at the University of Aberdeen, who argued that the planned increase of student numbers to 170,000, which will bring the proportion of students to total population in England to the same figure as it now is in Scotland, must (since there are no grounds to suppose that the English are more intelligent than the Scots) lead to the entry of a large number of students of lower calibre than hitherto, who will need easier courses of instruction. He assumed that the general degree in England can be equated to the ordinary degree in Scotland, and that there will be an increasing need for it, as providing a suitable education for the less-able student.

The second opening speech, given by Prof. F. C. Frank (professor of physics, University of Bristol), dealt with the general degree with honours provided by most of the English universities, and in particular with the general degree of B.Sc. He took the opportunity to direct attention to the appalling complexity and disparity of terminology employed by various universities in describing the courses they offer. But while the general honours degrees are of various structure from university to university, broadly speaking they differ from special honours degrees mainly in the third year of study, which in a special degree is devoted to a single subject, whereas it still covers two or more subjects in a general degree.

The distinction between the special and the general degree ought not, Prof. Frank said, to be regarded as one of merit. He gave it as his considered judgment that in practice it is harder to get a first class in the general than in the special degree, though easier to get a poor second or a third class. It is judged to be a suitable career education for school-teaching, a course of education suited to the type of mind which is less happy concentrating on a narrow front, and a more balanced course for those whose intended future is a non-academic one (whereas the more academic will yet have time to take up their various academic subjects in turn). In short, he considered it a suitable education for a Cabinet Minister.

Judging from newspaper reports of the discussion, it is probably the former conception of the general degree which appears more realistic outside university circles. This view was not without support at the Conference, but most speakers concerned themselves with the general honours degree: its merit was confirmed, but its name was brought in question. The

outstanding argument which can be made against the type of education given in a general degree was not brought into the discussion. This is Dr. C. R. Burch's principle, the broadening effect of specialization—if one studies chemistry, for example, superficially, it is chemistry only; the deeper one studies it, the more one is forced to discover its connexions with other subjects.

In the view of the University of Southampton, expressed by Prof. H. C. Baldry (classics), the general honours degree, under that title, has no future at all. It carries from the past (meaning, for Southampton, the period when it was under the tutelage of London) what according to this view is an indelible association with mediocrity. Southampton, in its regulations governing admissions since 1959, has abolished the general degree, but at the same time has provided a flexibility in the make-up of the course for an honours B.Sc. so that it is possible for it to be essentially similar to one of the less-wide general B.Sc. degrees, such as that provided at Bristol. Prof. G. Gee (Sir Samuel Hall professor of chemistry, University of Manchester), supporting the view that the choice between specialization and a wider curriculum is quite distinct from the need to provide courses at different intellectual levels, advocated a single B.Sc. certificate, with the appropriate class of honours, and the subjects studied, and for what periods, separately recorded on the certificate.

Against this view we have the policy, implied by the latest University of London regulations, and made explicit by Prof. J. G. Semple (professor of mathematics, King's College), that the general degree serves a dual purpose, being in its honours classes fully equal, and perhaps in the first class a shade superior, to the special degree, but in its pass category offering an easier route to a degree for the less-able student.

This is indeed how it tends to work out in practice, but it is a matter for urgent decision whether this dual purpose use is compatible with a proper recognition of the status of a good general honours degree. Prof. Frank, in his reply, considered that this was only possible if one made a strictly parallel division into general honours, general ordinary, special honours and special ordinary, even though ordinary specialists are the type of graduate which universities are least desirous of producing.

A distinct but important subject was brought into the discussion by Prof. W. F. W. Wynne-Jones (professor of chemistry, King's College, Newcastle on Tyne), namely, the danger that a general honours student may be nobody's baby. He suggested that interdepartmental professors—professors without portfolio—could take responsibility for these students, and Prof. Frank in his reply remarked that such interdepartmental professorships are being increasingly established in the United States, mainly to provide liaison between departments at the research-level. It was interesting to see in Prof. Wynne-Jones's proposal the way in which such interdepartmental professors could be given the opportunity to involve themselves with undergraduates.

F. C. Frank

# THE UNIVERSITY GRANTS COMMITTEE

## ANNUAL REPORT

THE annual returns from universities and colleges in Great Britain in receipt of Treasury grants for the academic year 1958–59, now covering 21 universities and 3 colleges, issued by the University Grants Committee, is this year prefaced by a somewhat longer summary of the Committee's major activities since June 1959*. Much time was given to consideration of possible changes in the university population during the 'sixties and 'seventies; and, following the Chancellor of the Exchequer's authorization in January 1960 to discuss with the universities the practicability of providing 170,000–175,000 places by the early 'seventies, the Committee asked the universities to consider what further expansion in student numbers they were prepared to contemplate by that date, together with their requirements for new accommodation. On the basis of subsequent discussions with the universities, the Committee has prepared a report for the Chancellor of the Exchequer. These discussions indicated that the existing universities, including the newly founded University of Sussex, could not of themselves alone provide a sufficient number of places, and that some new institutions were needed. The Committee therefore recommended to the Chancellor in March that immediate steps should be taken to encourage the establishment of new universities at Norwich and York, and authority to initiate such foundations was given in April.

After consultation with the Committee of Vice-Chancellors and Principals, the Committee has advised that these new institutions, which are to be multi-faculty, should have powers from the start to grant both first and advanced degrees, to set their own entrance requirements and to devise their own curricula. It is proposed that the safeguards previously achieved by close association with an existing university institution should be secured for a period by means of an Academic Advisory Committee consisting of members from existing universities and, possibly, with lay representatives. Possible means of assisting St. David's College, Lampeter, were explored during the year; a scheme has since been approved.

An independent sub-committee, with Sir William Hayter as chairman, was appointed to review developments in the universities in the field of Oriental, Slavonic, East European and African studies, consequent on the recommendations of the Scarbrough Commission in 1947, and to consider and advise on proposals for future developments.

An inquiry concluded during the year into the success or failure of students entering universities in October 1955 to study arts, pure science, technology, agriculture or forestry, showed that the proportion who left without success on account of academic failure was only 9·9 per cent, compared with 11·3 per cent in an earlier survey in 1952.

* University Grants Committee. Returns from Universities and University Colleges in receipt of Treasury Grant, Academic Year 1958–1959. Pp. 58. (Cmnd. 1166.) (London: H.M. Stationery Office, 1960.) 4s. 6d. net.

The Committee has continued to give thought to ways and means of ensuring the maximum economy in the expenditure of capital funds, and standards of accommodation of various types, based on analyses of comparable buildings, on which universities can base their applications to the Committee for grants for new accommodation, have been suggested. The Committee has also considered and adopted new methods, based on cost analyses, of assessing grants for halls of residence and for science buildings; the new system of assessing grants for science buildings distinguishes between the cost of the building with its basic requirements in the way of heating, lighting and ventilation and its special requirements in the way of services, which may vary greatly.

The number of full-time students in British universities increased further to 100,204, compared with 95,442 in 1958–59, and statistics collected in October 1959 showed a university population of about 102,000. There were 6,084 full-time and 2,270 part-time students from overseas within the British Commonwealth, and 4,116 full-time and 1,944 part-time students from foreign countries; for 1957–58 the figures were 6,180 and 2,208 for the Commonwealth, and 3,982 and 1,904 for foreign countries. Of full-time men students, 36·8 per cent were in arts, 24·2 per cent in pure science, 19·5 per cent in technology, and 12·5 per cent in medicine; these figures compare with 36·4, 23·7, 19·0 and 13·7 respectively, in 1957–58. For full-time women students, the corresponding figures for 1958–59 are 62·6, 20·7, 1·0 and 11·9, respectively, and for 1957–58, 63·5, 20·0, 0·8 and 12·1, respectively. Full-time advanced students of pure science numbered 4,071 (34·9 per cent); of technology, 2,125 (18·2 per cent); and of medicine, 900 (7·7 per cent); 3,185 students were taking post-graduate teacher-training courses.

Of the full-time students, 80,805 were reading for a first degree, 3,928 for a first diploma, and 14,839 were engaged in research or other advanced work; the corresponding figures for 1957–58 were 76,687, 3,937 and 14,069, respectively. Of the new full-time students, 24·1 per cent were in pure science, 16·2 per cent in technology and 8·9 per cent in medicine; in 1957–58 the corresponding figures were 24·0, 15·4 and 9·1 per cent, respectively.

The proportion of assisted students was 80·5 per cent compared with 79·2 per cent in 1957–58 and 71·9 per cent in 1953–54, ranging from 92·4 per cent in Wales, 87·5 per cent in English universities, excluding Oxford, Cambridge and London, to 70·6 per cent for Scotland. Full-time teaching and research staff increased to 10,823, compared with 10,542 in 1957–58. The proportion of full-time students residing in colleges or halls of residence was 26·6 per cent, compared with 26·4 per cent in 1957–58; 49·6 per cent were in lodgings and 23·8 per cent at home, but these proportions vary widely between men and women and between institutions.

Of the recurrent income of £52,273,306 (an increase of £2,855,004 in 1957–58), £36,448,118 was from Parliamentary grants (69·7 per cent), £5,739,316 (11·0 per cent) from fees, £1,795,344 from endowments, £1,500,918 from local authority grants, £479,093 from donations and subscriptions, and £3,657,530 (7·0 per cent) from payments for research. Non-recurrent grants in respect of capital expenditure amounted to £16,554,483, compared with £11,816,479 in 1957–58; and of the recurrent expenditure of £51,526,275—an increase of £3,191,222 on 1957–58—6·8 per cent was spent on administration, 44·5 per cent on salaries and superannuation of teaching staff, 11·0 per cent on departmental wages, 13·2 per cent on departmental and laboratory maintenance, 3·4 per cent on repairs and maintenance of buildings, and 9·7 per cent on rates, insurance, heating, lighting, etc. Expenditure on libraries, at £1,979,945, remained at 3·8 per cent of the total.

## WIND TUNNELS AND FLOW VISUALIZATION

THE Fluid Dynamics Panel of AGARD held technical sessions at Istanbul, Turkey, during October 3–4. Fifteen papers were presented, the two main topics being the 'industrial' use of wind tunnels, and flow visualization. The term 'industrial' used in this context means 'non-aeronautical'; and these topics were chosen for this particular meeting because of the special requirements of the host nation, which has little aeronautical industry. The meeting also presented a rare opportunity for workers in a field of aerodynamics which, while it does not usually receive the consideration of bodies concerned with aeronautics, is not afforded much prominence in the proceedings of the various engineering institutions to which the work is relevant.

The titles of the ten papers presented on industrial aerodynamics showed a similarity which was reflected to a large extent in the contents of the papers. Nevertheless the papers revealed a very wide diversity of problems, ranging from work on insect flight (using live subjects) to that of the aerodynamic oscillations of long suspension bridges. The introductory paper by Mr. C. Scruton (United Kingdom) gave a brief review of the work carried out at the National Physical Laboratory. This was classified under three main categories: (1) the study of flow problems; (2) the assessment of the steady-wind forces and pressures on vehicles, ships, buildings, etc.; (3) the oscillatory effects of wind on structures. The techniques used and the conditions for similarity of behaviour between the model and the full scale were briefly indicated. In the first category most of the work was concerned with the flow over the decks of ships, and with pollution from the effluent of industrial chimneys, either with regard to the adjacent buildings or to the surrounding countryside. The oscillatory effects of wind were dealt with at somewhat greater length, with particular mention of the oscillations which can be induced by an air-stream on suspension bridges or tall stacks, and in tube arrays, such as are found in heat exchangers. It is now usual to carry out aerodynamic stability tests in connexion with all major suspension bridge projects, and, for this purpose, it has been shown that costly

and time-consuming tests of aeroelastic models of the complete bridge are unnecessary and that the simple and cheaper 'sectional' model technique, in which a model of a representative length of the suspended structure is mounted on springs in the wind tunnel, is adequate. These tests have been usually carried out in a steady windstream, but on occasions it has been necessary to investigate the possibility of buffeting oscillations of the bridge arising from its immersion in the eddying wake of a nearby bridge. The wind-excited oscillations of tall circular stacks are usually in bending modes transverse to the wind direction, and are due to the alternating 'lift' forces produced by the shedding of vortices from alternate sides of the section. Whether or not a stack oscillates depends on the natural frequency (on which depends the critical speed for instability) and on the structural damping. Artificial structural damping has been used to suppress the oscillations, but it may be that a more satisfactory solution is to be found in modifications to the cross-sectional shape which destroy the aerodynamic excitation. One such device which has proved successful was developed at the National Physical Laboratory, and consists of a three-start strake wound helically round the surface of the stack. This has the effect of destroying the regular periodicity in the formation of vortices. The top of a stack may be forced also into oscillations as an elastic ring by the action of the vortices. A ciné-film was shown which records such an occurrence at a power station in England and provided a graphic illustration of this effect.

The paper by Mr. P. J. Pocock (Canada) provided a most complete review of the industrial uses to which wind tunnels have been put in various countries, together with a comprehensive bibliography of no less than 385 references. The range of subjects investigated is very wide: meteorology, water conservation, soil erosion by wind, the mechanics of wind-driven snow, dust transport, are included as well as those discussed by Scruton. The aerodynamics of sails is now receiving attention at the University of Southampton. Pocock also referred to the work on animal flight which has been carried out in wind tunnels. This ranges from the testing of dead or sculptured birds to the more intriguing measurements on live insects which were tethered on a delicate and intricate wind-tunnel balance and their performance in flight measured as they flew against the horizontal wind.

In his paper on the aerodynamic problems of motor-cars Prof. H. Schlichting (Germany) demonstrated the very considerable saving in fuel consumption which has been achieved on the Volkswagen lorry by a modification to the frontal shape suggested by wind-tunnel tests. Reference was also made to the use of such tests to obtain data required for assessing the directional stability at high speeds of the Volkswagen private car, and of the stream-lined *NSU* motor bicycle which attained the world's speed record.

Prof. G. H. Strom (United States) discussed several interesting aspects which had been studied at New York University. With the reduced linear scale necessary, the representation in a wind tunnel of portions of the atmosphere, to include motions of mechanical and thermal origin, was a complex problem. The determination of the appropriate scale criteria needed further development, particularly when convective air currents were significant. Prof. Strom mentioned experiments in which powdered borax had been used to simulate snow in tests of snow drifting, and tests to study the production of capillary waves on a water surface.

A brief paper by Mr. H. Petersen (Denmark) described a wind tunnel especially suited for work in industrial aerodynamics. The tunnel design was based on the model-law proposed by Dr. Martin Jensen to provide the correct simulation for phenomena in which the influence of the vertical gradient of wind speed near the ground is significant.

The range of the problems investigated in wind tunnels was extended still further by the subsequent speakers. At Lille, A. Martinot-Lagarde (France) has studied mine ventilation, the fluid-flow in heat exchanges, and, more remarkably perhaps, the drag of fishing nets. A surprising result of the last-mentioned tests was that the drag of a net of nylon material was only 0·7 that of a net of similar configuration in cotton.

An open-jet type wind tunnel at the National Luchtvaarlaboratorium has been used extensively by Mr. N. Feiss (Netherlands) for investigating a wide variety of industrial problems. Some interesting techniques have been developed for predicting the nuisance caused by the deposition of rain and snow on the windscreens of vehicles.

Profs. R. Clay Porter and F. K. Boutwell (United States) have used the low-speed wind tunnel at the University of Michigan for some detailed work on air pollution from industrial effluents. An investigation at present in progress concerns natural draught cooling towers. It is claimed that such work has resulted in considerable financial savings by the industry.

The subject-matter of the two remaining papers, by Mr. R. F. Creasey and Mr. K. Emslie (United Kingdom), "Industrial Uses of Wind-tunnels with Particular Reference to Wind Machines", and by Mr. L. E. Leavey (United Kingdom), "Wind-tunnel Tests to determine the Efficiency of a Proposed Extension to a Welding Shed on Suppressing Draughts", may be gathered from their titles. It may be noted that these were the only papers to describe work of a non-aeronautical character carried out in the wind tunnels of aircraft manufacturing firms. Such investigations have been mostly carried out either by the universities or by national scientific establishments. The subjects treated and the techniques described in the papers from the several countries were broadly similar. However, there were sufficient differences to avoid repetition, and to make all the papers very valuable and worth-while contributions to an art which is rapidly increasing in its importance and in its application to engineering design.

The first of three papers on flow-visualization was presented by H. Werle (France), and described a number of facilities, using water as the fluid medium, which allow qualitative work to be carried out on problems of air-flow. These facilities included a narrow tank for viscous-flow work, a water tunnel for incompressible flows, and a free-surface tank for the supersonic analogy. The paper was given with the aid of an excellent ciné film in colour, the use of dye streamers of different colours enabling three-dimensional flows to be followed very easily. Among the phenomena shown in this film were the flow of swept wings in which the leading-edge vortices 'burst' at a little distance downstream, the effect of 'blowing' over flaps and ablation effects on a bluff body. For the latter experiment the body was moulded in ice,

but no similitude with the full-scale phenomenon was claimed.

Mr. R. L. Maltby (United Kingdom) based his presentation on one of five papers which have been prepared for an AGARDOgraph on flow-visualization, and which describes the methods used in British low-speed wind tunnels. In addition to the usual 'smokes', mention was made of the use of soap bubbles. Condensation trails can form a natural method of visualizing the leading-edge vortices from swept wings when the vorticity is of sufficient strength to produce the condensation.

Moving from methods suitable for use in low-speed tunnels to those for high-speed flow visualization, J. L. Solignac (France) described interferometric apparatus used at the Office National d'Etudes et de Recherches Aéronautiques. One of these employed split-beam interferometry, whereas the other, which was developed there, was a schlieren-interferometer system using polarized light. As compared with the ordinary schlieren system, the latter method was claimed to have the advantages of simplicity as well as of the ability to make quantitative measurements.

C. Scruton

# PRIMARY AND INITIAL EFFECTS OF IONIZING RADIATIONS

PROF. G. M. FRANK organized in Moscow during October 18–22, on behalf of the Academy of Sciences of the U.S.S.R., an international symposium which was sponsored by Unesco and the International Atomic Energy Agency. Half the thirty participants came from countries other than the U.S.S.R. As the contributions ranged widely and encompassed several disciplines, the classification under the headings chosen for this report must be somewhat arbitrary.

## Interference with Intracellular Structures

The concept that the initial radiochemical reaction leading to the death of a cell is brought about by interference with the intracellular organization of the cell found support from many of the participants. In the first of the scientific papers, P. Alexander (London) reviewed the chemical data concerning damage to proteins and nucleic acids by ionizing radiation, and concluded that reactions of this kind, although they occur in cells, as do many others, did not meet the requirements for the radiochemical events that initiate cell death. He suggested the phospholipids of the intracellular membranes as a more probable site. Since one of the most frequent and earliest biochemical lesions following irradiation is an increase in enzymatic activity, it had been proposed by Bacq and Alexander (enzyme-release hypothesis) that radiation interferes with the structures within the cell that are responsible for its essential compartmentalization. G. M. Frank (Moscow) provided a striking demonstration of an increase in metabolism within an hour of irradiation by showing that the time taken for oxygen-levels in the brain to return to normal after a short period of inhalation of pure oxygen was less in an irradiated animal. The same technique also revealed that radiation immediately interferes with the homeostatic maintenance of oxygen-levels in tissues.

L. A. Stocken (Oxford) and M. Errera (Brussels) described their experiments on the immediate effect of X-rays on the metabolism of the nuclei of rat thymocytes. Stocken concluded that low doses produce local disorganization of the nucleus, which alters binding sites, and he outlined his current research programme directed to discovering the factors that maintain the nucleus in an organized state. Changes in the structure and behaviour of cytoplasmic fine structures within minutes of irradiation were seen by M. N. Meissel (Moscow) using fluorescent vital staining and by A. Shabadash (Moscow) with histochemical techniques. O. Hug (Munich) reported that smooth muscle was unexpectedly radiosensitive, and contracted with a dose of a few hundred röntgens so long as this was given at a sufficiently high dose-rate. He interpreted this effect as a temporary change in permeability of the nerve (or muscle) membrane.

A. M. Kuzin (Moscow) observed mitotic inhibition in the tip of the bean root (*Vicia faba*) although only a leaf had been irradiated. An antimitotic substance could be extracted from irradiated leaves and on purification was shown to be a soluble oxidation product of a polyphenol (a quinonoid substance). Evidence was found in support of the view that the active substances were formed as the result of the release (activation ?) of enzyme peroxidases from cytoplasmic organelles.

A. J. Passynsky (Moscow) was led by general kinetic considerations to the view that death of a cell by radiation was due to interference with the orderly sequence of biochemical events due to damage to the interphases at which they occur. Experiments in a model system illustrated the breakdown of membranes by 20,000 r. of X-rays. Particles of an enzyme were coated with a layer, approximately 100 A. thick, of ribonucleic acid and then suspended in a solution of substrate. Enzymatic activity was accelerated on irradiation because the permeability of the ribonucleic acid film was increased. N. N. Doemin (Moscow) carried out a very detailed study of the effect of radiation on the lipids and lipoproteins in different sub-cellular fractions (microsomes, mitochondria); surprising differences were observed in different organs of the rats, though in every case early lesions among lipids were observed.

B. N. Tarusoff (Moscow) has found that the concentration of lipid peroxides in tissues of mice increases with time after irradiation, which initiates the oxidation chain. A correlation was seen between the peroxide-level and the time of death of the animal, and Tarusoff supports the view advanced some years ago by J. St. L. Philpot that toxic peroxides contribute to radiation death in mammals.

Genetic techniques using 'sexual' transfer between biochemically deficient mutants were used by H. Marcovich (Paris) to show that the killing of *E. coli* (that is, the loss of ability of the cells to proliferate indefinitely and form colonies) could not be attributed to a dominant lethal mutation. K. Tobias (Berkeley), on the other hand, argued that killing of yeast and the very complex relationship between ploidy and radiosensitivity could be adequately explained as the

combined action of dominant and recessive lethal mutations.

A comprehensive mathematical formulation of the processes leading to cell death was presented by A. V. Lebedinsky (Moscow), who considered the simultaneous occurrence of repairable interference with metabolism and irreversible blocking of mitosis.

## Modification of Radiation Damage

Death of a cell, rate of mitosis, chromosome damage, mutation production can be altered by a variety of post-irradiation treatments in unicellular organisms and some plant materials. N. I. Shapiro (Moscow) has now found that chromosomal damage in Ehrlich mouse ascites cells irradiated *in vitro* and then injected back into the animal can be substantially reduced if the cells are suspended in a medium containing arginine for 1 hr. after irradiation. A. Hollaender (Oak Ridge) reported that genetic damage in *Paramecium* could only be repaired if the post-irradiation treatment was begun before chromosome duplication had occurred. Shapiro's data could bear a similar interpretation. Powerful synergism in the amount of chromosome damage was found at Oak Ridge if a dose of X-rays was followed by ultra-violet irradiation within a comparatively short time. F. Heřčik (Brno) demonstrated that the treatments that result in the recovery of *Paramecium* also lead to recovery of the phage-synthesizing capacity of *E. coli* in spite of the fact that doses of the order of $5 \times 10^5$ r. are needed to inhibit this synthetic process. Another Czech scientist, J. Soška, finds that the regeneration of bone-marrow *in vivo* is significantly increased by the administration of cytidylic and thymidylic acid, but not by purine nucleotides. Interference by radiation with deoxyribonucleic acid synthesis of bone-marrow cells *in vitro* is reduced by the addition of triphosphates to the medium.

The reduction of the killing action of X-rays for mammalian cells in tissue culture by fractionation had been interpreted as evidence that post-irradiation restoration processes occur normally. On repeating these experiments with x-rays from polonium, J. W. Barendsen (Netherlands) could find no evidence for recovery, suggesting an important qualitative difference between densely and sparsely ionizing radiations.

Radiation response can also be modified by treatments that have to be given before and during irradiation. L. H. Gray (London) provided further evidence that the radiosensitizing action of oxygen cannot be attributed to early post-irradiation metabolic processes, but that it must be connected with the immediate radiochemical events. The phenomenon is, however, far from simple, and B. N. Tarusoff (Moscow) has shown that there is an optimum oxygen concentration for sensitization in the case of yeast cells. If the amount of oxygen in the atmosphere exceeds 80 per cent the cells become less radiosensitive. This observation is interpreted as support for the view that a branched, oxidative chain-reaction is involved in the initiation of radiation damage.

The mechanism of radiation protective agents received much discussion. Z. M. Bacq (Liège) stressed that the almost universal protective action of cysteamine arose from the fact that this substance could protect by at least three different physico-chemical mechanisms: radical capture, energy transfer and 'repair' by transferring a hydrogen atom to an organic radical. There was no reason for believing that in biological systems the same chemical mechanism was involved in every case. In mammalian systems radical capture or 'repair' seemed the most probable and the suggestion that cysteamine protected mammals by producing anoxia had to be rejected. This view was strongly supported by the extremely detailed investigations of E. Y. Grayevsky (Moscow). His group showed that the protective action of hypothermia, neurotropic substances and substances combining with haemoglobin, but not of cysteamine, was directly attributable to a fall in oxygen tension in the radiosensitive tissues to less than half the normal value. L. H. Gray (London) showed that the protection of cell suspensions *in vitro* by aliphatic alcohols was also not related to the oxygen effect. Evidence that protection against the mutagenic action of X-rays is independent of protection against death of the cells was presented by A. Hollaender (Oak Ridge). $10^4$ r. kills no cells of *Aspergillus terreus*, but the number of mutations produced by doses of this order is greatly reduced by cysteamine.

P. Alexander (London) interpreted his results on radiosensitization as showing that substances which are normally present in the cell can act as intracellular protective agents. Blocking of sulphydryl groups of lymphoma cells by iodoacetate was responsible for the radiosensitization of these cells by this substance. The great variation in the radiosensitivity of micro-organisms may in part at least be due to the presence of particularly effective intracellular protective substances; for example, carotenoid pigments.

## Radiosensitivity of Biological Macromolecules

E. C. Pollard (Yale) described the use of radiation as an analytical method for determining the size and shape of functional units within cells. He deduced that the organelle responsible for protein synthesis was a unit having the weight of a microsomal particle, but with highly asymmetric shape. This quite unexpected finding receives striking support in recent electron microscopic studies on sections of frozen dried cells which have suggested to some workers that the microsomal particles can assume a sheet-like character. L. H. Gray (London) interpreted death of a bacterial cell as a single-hit target event, since he finds the dose-response curve to be accurately exponential over a vast range. On the other hand, J. W. Barendsen (Netherlands) finds that a target type interpretation cannot be applied to mammalian cells since the log (survivor) v. X-ray dose-curve never becomes truly linear and increases continually in steepness. K. Tobias (Berkeley) presented data showing that the determination of 'target sizes' was impossible even for isolated pure proteins, as there was interaction between particles.

L. A. Blumenfeld (Moscow) gave a detailed review of what can be learnt from the electron spin resonance patterns of irradiated proteins and nucleic acids and provided further evidence for his own well-known theories on the presence of conduction bands in native proteins. The use of electron spin resonance for discovering the nature of the initial lesion is very limited, as almost all cell constituents give rise on irradiation to radicals. All these radicals are seen by electron spin resonance, although many of them have

no part in the biological effects. E. L. Powers (Argonne, U.S.A.) used the electron spin resonance method to good effect to confirm the presence of a number of different types of trapped free radicals which remain in the dry spore after irradiation. He observed that post-irradiation treatments with hydrogen sulphide and nitric oxide reduced the number of spores rendered non-viable, while exposure to oxygen enhanced damage. Electron spin resonance measurements indicated that these effects were due to reaction with trapped radicals. In swollen systems, such as vegetative cells, radicals have only a very short lifetime, and to be detected a 'flash radiolysis' technique has to be used. L. H. Gray described some results obtained in this way. Mrs. B. Holmes (Cambridge) described experiments of J. S. Mitchell which revealed the existence in irradiated mammalian tissues of relatively long-lived excited molecules that emit ultra-violet light after irradiation.

Peter Alexander

## COKE RESEARCH

NOT all annual reports of technical, or even non-technical, activities provide an absorbing story of events of interest to others than the specialist. The sixteenth annual report of the British Coke Research Association, however, is noteworthy for a new feature in the form of a very clearly expressed appendix, in which an attempt is made to clarify the objectives of the programme of research*. Any likely developments that may point to the future importance of coal should be of interest to many engineers and technologists, and indeed to quite a number of laymen engaged in pursuits perhaps of greater philosophical calm. Particularly so must be the situation at the present time, when one hears so much of the potentialities of oil and nuclear fuels, and when hoping that the price of coal was tending to find a stable keel, one is startled by new economic storms. In a refreshing and lucid manner the research objectives of an important industry on which the future of steel and coal must depend to a substantial measure are set out in a manner that brings conviction of the care and thought given to their preparation.

The interested reader will learn that 40 per cent of the research effort of the British Coke Research Association is devoted to the improvement in quality and yield of metallurgical coke, and that a further 28 per cent is devoted to work designed to throw light on phenomena and factors that govern the efficiency of use of all types of coke.

The modern blast furnace requires a coke of consistent quality in respect of its physical and chemical properties. The Coke Research Centre at Wingerworth has its small experimental ovens and the industrial scale 10-ton oven in which the various factors may be worked out to enable the optimum conditions to be arrived at for the carbonization of a 'standard' coal. At the same time, attention is devoted to the yields and nature of the by-products from the point of view of the efficiency and economy of the coke-oven process in general.

In the scientific work on coke the more advanced techniques of physical science such as X-ray diffraction have long been used. The latest techniques, that are now finding a place in the elucidation of a workable understanding of the structure of carbon and the texture of coke, are concerned with magnetic susceptibility and microwave absorption. Perhaps the lessons of the value of the more abstruse techniques necessary in fundamental investigations are not lost in these days on the comprehension of the layman, even if the mysteries of the techniques themselves seem to provide rather heavy going. In the present instance the ultimate answer may well be the means of production of cokes, capable of superior performance in use, from supplies of coal of unexpected suitability.

In the programme of research two other broad fields of interest are considered: first, the magnitude and complexity of the coke oven effluent and atmospheric pollution problems; and secondly, new methods of making blast furnace coke. In the former, the problem becomes an issue common with many other industries, and it is thus only a part of a larger national issue being considered by the Department of Scientific and Industrial Research. In the latter the matter is at the design-study stage where the fundamental requirements of the problem have to be analysed, the estimates of the chances and conditions of success determined, and some practical course of research devised.

The report of the achievements of the year covers not only the work on the new full-scale test plant but also that of the fundamental and applied studies laboratories at Wingerworth, and the progress achieved by work in the universities, notably at King's College, Newcastle upon Tyne. In this last case the technique of electron resonance absorption has been used to follow in the course of coke formation the development of reactive centres, described as 'free radicals'. They are formed in coke at temperatures up to 800° C., and play a part in the fixation of sulphur as organic sulphur in coke. At the University of Leeds work on the flow of heat in the coke oven during carbonization has been prosecuted with the application of a digital computer. This work constitutes a further proof of the potentialities of the use in this manner of the unsteady heat conduction equation in the solution of practical problems.

Also of specific interest to scientist and technologist alike is the correlation found, almost to a surprising degree, between the results of the performance in carbonization from a 5-cwt., a 10-ton oven, and even a commercial battery. Practical trials on cupolas have settled the question of the effect of coke size in iron melting, and have shown that a 3–1 in. coke size may be used successfully in hot-blast cupolas.

A very wise decision has been not to allocate 15 per cent of the effort of the Association to any strictly defined objective. For is there not force in the argument that on the border of the unknown there is needed the keener search? Alike, as in diagnosis, the less definite the symptoms the greater the need for the sensitive touch!

* British Coke Research Association. Sixteenth Annual Report for the year 1959. Pp. 40. (Chesterfield: British Coke Research Association, 1960.)

## SOLID-STATE PHYSICS AT MELBOURNE

A SUMMARY of the proceedings and notes on the papers presented to the conference on solid-state physics held in Melbourne during August 17–21, 1959, under the auspices of the Australian branch of the Institute of Physics, has been published in the *British Journal of Applied Physics* (**11**, 137; 1960). The conference was the first of its kind to be held in Australia, and there was an attendance of about 130. Financial assistance in the form of grants was received from the Australian Atomic Energy Commission, the Commonwealth Scientific and Industrial Research Organization, the Australian Academy of Science, the Universities of Melbourne and New South Wales, and several industrial concerns. Forty-six papers were read and discussed at the conference, and the texts of a number of the original contributions have now been published in a special issue of the *Australian Journal of Physics* (**13**, No. 2.4; July 1960).

Prof. C. S. Barrett, of the University of Chicago, discusses the structure of the semi-metal bismuth at low temperatures, and describes a precision determination as a function of temperature of the displacement parameter of zone-refined bismuth containing less than 0·3 part per million of spectroscopically detectable impurity. The small but significant dependence on temperature at low temperatures disagrees with predictions from Blount and Cohen's theory and may signify a decrease in resistance to atom displacement from the simple cubic structure because of the thermal expansion of the structure.

Dr. J. J. Gilman, of the General Electric Research Laboratory, contributes an interesting paper in which he presents evidence to show that crystals exhibit a plastic resistance to dislocation motion. Direct observation of such resistance has been made with lithium fluoride and ferrosilicate crystals. The yield stresses and indentation hardnesses of many crystals can be correlated with their elastic moduli, and therefore the elastic modulus is one important factor which determines the plastic resistance. Another is the crystal structure type. Several papers deal with thermal transport in alloys, and individual papers with the nucleation and growth of ice crystals on crystalline substrates, X-ray measurements in metals, and the photographic process as a diatomic reaction.

## SCIENTIFIC RESEARCH IN BELGIUM

THE annual report for 1959 of the Institute for the Encouragement of Scientific Research in Industry and Agriculture, Brussels, records research grants totalling 192,507,902 francs and grants amounting to a further 7,128,750 francs for special courses and travel; 65 of the 79 grants for special courses were in chemical sciences and 7 in agricultural science*.

Of the research grants, one of 19,945,000 francs was for a systematic investigation of the pedological character of Belgian soils, and the completion of the pedological map of the country; 13,220,000 francs were for the continuation of researches on the physics of the solid state in the laboratories of Prof. Dekeyser at the University of Ghent, of the Electrical Construction Factory at Charleroi, of Prof. Brasseur at the University of Liège and of the Gevaert Factory; 11,200,000 francs to the Scientific and Technical Research Centre of the Metal Industry for research on the metallurgy of steel and special ferrous alloys, and a further 1,825,000 francs for soldering research; 3,900,000 francs to the Carbochemical Society of Tertre for research on textile dyeing; and 6,750,000 francs to the Gevaert Photoproducts Society for work on photographic dyes and processes of colour photography.

The Committee for the Application of Isotopical Methods in Agronomic Research received 9,485,000 francs for the continuation of researches on the utilization of radioisotopes, the Hainault Section of the National Centre for Metallurgical Research 7,770,000 francs for investigations on furnaces, 4,865,000 francs for its work on the continuous fusion of steel, the resistance of steel to brittle fracture, the improvement of converters, etc.; and the General Metallurgical Society of Hoboken 7,560,000 francs for work on tantalum, niobium and their conversion to massive metal. Further subsidies of 2,905,000 francs and 4,455,000 francs went to the National Centre of Metallurgical Research and the Scientific and Technical Research Centre of the Metal Industry, respectively, for continuation of research on the mechanical properties of steel and improved methods of utilizing steel. The Liège Section of the former received a further 6,891,500 francs covering Belgian participation in the work of the International Committee for Research on Low Temperature Furnaces and 6,200,000 francs for continuation of research on cobalt. The Committee for the Study of the Nitrogen Problem received 6,520,000 francs for its studies on nitrogen in Belgian soils and on the fixation of nitrogen by legumes; the Centre for the Biological and Colloidal Chemistry of the Soil, 6,395,000 francs for work on the formation of the organic matter of the soil and on the soil colloids; the Research Centre of Gorsem, 5,500,000 francs for its researches on horticultural and agricultural diseases and pests; the Scientific and Technical Centre of Belgian Textile Industry, 5,109,500 francs for new research on the manufacture of fibroplasts, on the carding of wool, on the utilization of isotopes for investigating the spinning of cotton and on the inter-relation between the properties of the threads and fibres of cotton; the Biological Forestry Centre of Campine limbourgeoise, 4,800,000 francs for pedological, entomological, genetic and sylvicultural research bearing on the improvement of exploitation, conservation and

* Institut pour l'Encouragement de la Recherche Scientifique dans l'Industrie et l'Agriculture. Rapport Annuel. Exercise 1959. Pp. 237. (Bruxelles: Institut pour l'Encouragement de la Recherche Scientifique dans l'Industrie et l'Agriculture, 1960.)

natural regeneration of forests; and the Agricultural Physicochemical Centre, 3,960,000 francs for work on an improved method for the chemical determination of the nutritive elements in soil and the interpretation of the analytical results.

Grants of 3,155,000 francs and 2,670,000 francs went to the Scientific and Technical Research Centre of the Explosives Industry and the Centre for Research on Plant Hormones, respectively; 2,630,000 francs to the Centre for Research on Parasite Diseases of Domestic Animals; 2,400,000 francs to the National Committee for the Study of Fruit Cultivation for the equipment of two large conditioning chambers; 2,365,000 francs to the Centre for the Study of the Forest Soils of Ardenne and of Gaume for research on types of forest humus, and 2,240,000 francs to the Centre for Research on Diseases of Ornamental Plants. The Committee for the Study of Agriculture received a grant of 1,975,000 francs; the Plant Physiology Laboratory of the Gorsem Research Centre, 1,890,000 francs to extend its researches on the maturation of fruits and their conservation and studies on photosynthesis and on the influence of insecticides and fungicides on the physiology of the vegetables on which they are used; the Centre for Phytopharmaceutical Research, 1,836,000 francs for research on the utilization of phytopharmaceutical products; and the Committee for the Study of the Solid State, 1,650,000 francs for research on the production of durable magnetic materials.

Among other grants are 1,610,000 francs to the Pedological Service of Belgium, 1,412,000 francs to the Technical and Scientific Centre of the Wood Utilization Industry, 1,410,000 francs to the Committee for Strawberry Research, 1,350,000 francs to the Committee for the Study of Creep of Metals, 1,230,000 francs to the Belgian Centre for the Study of Corrosion "Cebelcor" and 1,080,000 francs to the Committee for the Scientific Study of Lactation.

## MYOCARDIAL TISSUE CHANGES ASSOCIATED WITH RIGOR MORTIS

INITIAL tissue changes associated with rigor mortis do not appear simultaneously throughout the myocardium, their onset being earlier in some areas than in others; such changes result from biochemical modifications occurring after death in myocardial fibres, that is, post-mortem dephosphorylation of adenosine triphosphate and disappearance of creatine phosphate. The evidence from an investigation by Piero Gallo, of the Tumour Control Research Centre, Rome, indicates that the adenosine triphosphate and creatine phosphate content in the areas first involved by rigor mortis is significantly smaller than that found to be present in other tissue areas (*Cardiologia* **37** Supp. 1; 1960). Since adenosine triphosphate and creatine phosphate represent the last link in the long chain of reactions involved in the production of chemical energy, the results enable the rate of this metabolic stage in different tissue areas to be evaluated quantitatively.

Far from being uniform throughout, the rate of energy production appears to be lower in areas where microscopic signs of rigor mortis begin, because these areas have the lowest content of adenosine triphosphate and creatine phosphate; the areas first involved by rigor mortis are segments averaging 20$\mu$ in length of cardiac muscle fibres, the whole width of which is affected.

The non-uniform distribution of adenosine triphosphate and creatine phosphate in the myocardium has been compared with the results of investigations concerning (*a*) the distribution of interfibrillar cytochondria, which is remarkably uniform; and (*b*) the diffusion speed of oxygen and energetic materials from the capillaries to the fibres, which varies in tissue areas.

These variations chiefly affect the aerobic phase of metabolism as well as the concentration of creatine phosphate and adenosine triphosphate, which is lower in more slowly oxygenated areas.

Analysis of these experimental findings enables the following conclusion to be drawn: the relatively small amount of adenosine triphosphate in some myocardial areas is not dependent on the distribution of cytochondria, but appears to be due to the fact that such areas are supplied with oxygen at a slower rate than the remaining tissue areas. The slow rate of gas exchanges in such areas seems to be responsible for a marked decrease in the yield of oxidative phosphorylation processes, so ensuring the transfer of chemical energy derived from breakdown and oxidation of energetic materials to creatine phosphate and adenosine triphosphate, which retain it and yield it to myocardial fibrils at the time of contraction.

In the rabbit, topical application of $\gamma$-hexane on the skin at a dose-level of 2 mgm./kgm. body-weight does not alter the course of myocardial tissue changes associated with rigor mortis, which exhibit a pattern almost identical to that observed in animals not treated with this insecticide.

## BOWER-BIRDS

THE popular belief that the display of bower-birds is either indiscriminate or satisfies some conscious aestheticism has been questioned by Prof. A. J. Marshall, of Monash University (*Endeavour*, **19**, No. 76; October 1960). He suggests that, remarkable as they are, the bowers and display paraphernalia of bower-birds are no more than an extension of the territorial and display impulses to be found in other birds. Avian display—visual and auditory—is usually associated with conflict and the establishment of territorial domination, pair formation, and seasonal gonad development; final synchronization of the sexual processes of the pair occurs when the environment changes seasonally to a state appropriate for successful reproduction. Only then will the female accept the male. All kinds of widely unrelated birds —for example, waders, grouse, manakins and lyre-birds—make simple display-grounds and posture on

them during their sexual season. These arenas are evidence of convergent evolution.

In bower-birds a simple display came first. The ontogeny of the satin bower-bird's display can be seen in the increasing elaboration of its ritual as the individual gains in maturity and experience. By scattering a few fragments of blue glass under a wild fig tree on which the young were feeding, Marshall was able to stimulate them to fly down, to snatch up the glass, and to display even without a bower. Later the young green males would build a simple platform of a few twigs and display there with the accumulated coloured objects; generally these would be stolen from neighbouring adult blue males and carried off to their bowers. As the young green birds grow older, they make low-walled avenue bowers, but before they themselves change colour at the age of five or six years to a mature blue-black they are capable of building a bower as elaborate as that of their elders.

Marshall sees the bower as a result of a displaced nesting-drive. The male, which takes no part in nest building, erects a structure on his display arena. The bower-birds have developed this display tendency—known in various other species—to an extraordinary degree; some species select coloured objects in the image of male rivals and use them violently in a noisy display which attracts the female and deters interlopers. Strong intraspecific competition has been a powerful factor in the evolution of bower-bird display.

Much has been written about the supposed intelligence of bower-birds, but there is evidence that they are no more intelligent than other highly developed passerine species. Much, too, has been written of their alleged conscious artistry; but their choice is essentially mechanical and unvarying. A species that uses greenish-yellow, for example, will never select green. None, so far as is known, ever varies its colour scheme.

# RADAR ECHOES FROM THE AURORA AT 1,300 MC./S.

By Dr. E. EASTWOOD, G. A. ISTED and J. D. BELL
Marconi's Wireless Telegraph Co., Ltd., Great Baddow, Essex

DURING the course of radar experiments directed primarily to the study of the movements of 'angels' and various types of cloud forms, we have recorded some very interesting radar echoes from the aurora at a wave-length of 23 cm. The observations have been made with a high-power *L*-band radar possessing the following system parameters:

| | |
|---|---|
| Radar frequency | = 1,306 Mc./s. |
| Pulse recurrence frequency | = 100 p.p.s. |
| Pulse-length | = 5 μsec. |
| Power | = 2 MW. |
| Aerial rotation | = 4 r.p.m. |
| Horizontal beam-width | = 0·7° (between half power points) |
| Vertical polar diagram | = $\mathrm{cosec}^2$ (lobe maximum at 1·6°) |
| Polarization | = horizontal |
| Aerial gain | = 10,000 |

During the two years of observations with this equipment the following three sets of auroral echo records have been secured:

| Date | Duration of radar aurora |
|---|---|
| July 15, 1959 | 15.50–17.15 U.T. |
| April 1, 1960 | 14.00–17.50 U.T. |
| October 6, 1960 | 16.50–18.25 U.T. |

The appearance of the radar aurora as seen on the plan position indicator at 17.43 U.T. of October 6 1960, is shown in Fig. 1. This record shows those essential features of the fully developed aurora which have been substantially reproduced on the occasions listed above, namely, the presence of two auroral arcs, the ranges of the extremities of which lie between 600 km. and 1,200 km., the azimuthal position of the arcs and their lateral extent. The rapidly changing form of the aurora is rendered vividly apparent by the method of time-lapse photography whereby photographs of the plan position indicator are taken so that successive scans of the aerial occupy consecutive frames of a ciné film. Projection of such a film through an ordinary ciné projector running at 16 frames per sec. gives a time compression factor of 240; this technique permits the movements of the auroral forms to be clearly observed and measured. The real or apparent motions of the scattering electron clouds within the auroral arcs will be discussed elsewhere; but it is of interest to note that there is a marked tendency for the western limb to show a preponderance of 'receding' clouds.

An interesting feature of the observations of July 15, 1959, was that this auroral record followed a series of plan position indicator photographs taken at sunrise (03.59 U.T.) on the morning of July 14 when the disturbed state of the Sun was made manifest by the greatly enhanced solar noise signal received by the radar. These two direct observations, on the one radar equipment, of the solar disturbance and the subsequent aurora set a time-interval between the two events of 36 hr.; this figure has to be increased to 36½ hr. when the time of first onset of the solar disturbance, as observed by S.I.D.s in the eastern hemisphere, is allowed for. (Solar flare, importance 3+, 03.25 U.T., 14.7.59.) Such a time-interval would correspond to an average velocity of the particles emitted from the Sun of the order of 1,133 km./sec.

Examination of the advices of magnetic data issued by the Eskdalemuir Observatory shows that

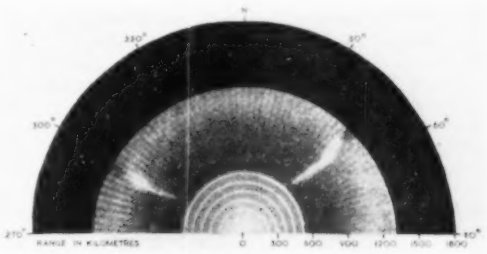



Fig. 1. Radar echoes from the aurora on 1,300 Mc./s. (17·43 hr., October 6, 1960)

the usual disturbance to the *H*-field there is of the order of 100–300γ. For April 1, 1960, however, disturbances of 2,600γ were recorded, while the magnetic storm of July 15, 1959, was even more violent in that disturbances of 4,100γ were observed. Survey of the records since 1949 shows that there have been only 21 occasions during the past 11 years when the disturbance in the *H*-field has exceeded 1,000γ; if these events are listed in order of diminishing intensity, then the first six entries appear as follows:

List of Magnetic Disturbances (1949–60)

| Order | Year | Date | *H*-disturbance (γ) | Radar aurora (1,300 Mc./s.) |
|---|---|---|---|---|
| 1 | 1959 | July 15 | 4,103 | Observed |
| 2 | 1958 | February 11 | 2,762 | Equipment not in use |
| 3 | 1960 | April 1 | 2,592 | Observed |
| 4 | 1957 | January 22 | 2,340 | Equipment not in use |
| 5 | 1957 | September 4 | 2,300 | Equipment not in use |
| 6 | 1960 | October 6 | 2,280 | Observed |

It is clear from this correlation between the occurrence of the radar aurorae reported in this article and the intensity of the magnetic disturbances as recorded at Eskdalemuir that only the more violent solar eruptions are likely to produce disturbances in the Earth's ionosphere of intensity sufficient to yield auroral echoes on a radar operating at so high a frequency as 1,300 Mc./s.; such events are likely to be comparatively rare.

The nature and spatial distribution of the radar echoes obtained at very high frequency during auroral activity have been studied by a number of workers; these investigations have clearly established the existence of aspect sensitivity in auroral radio reflexions. Chapman[1] has described the geometry of the reflexion process on the assumption that the reflecting 'rays' of the aurora are lying along the lines of force of the geomagnetic field, this latter being represented by the field of the equivalent centred dipole. Booker[2] has sought to reduce the degree of aspect sensitivity suggested by Chapman by a theory of scattering which postulates non-isotropic irregularities in the density of electrons in the aurora, such regions having their major axes parallel to the Earth's field. Booker[3] has applied his theory to the scattering of radio waves at frequencies up to 100 Mc./s., and in his treatment he assumes that the electron density in the aurora is increased only by a factor 10 over that normally obtaining in the *E*-layer. Fricker *et al.*[4] have obtained substantial agreement between the positions of auroral echoes observed at 400 Mc./s. and the areas of reflexion derived by approximate specular reflexion from columns of electrons lying along the Earth's field lines; in this analysis the actual Earth's field appropriate to the location of their radar stations was employed as distinct from the field inferred from the equivalent dipole approximation. The same process of specular reflexion was suggested by Peterson[5] to be the explanation of certain middle latitude echoes of auroral type, and Watkins[6] has shown that specular reflexion is closely obeyed in the case of the auroral echoes obtained at Jodrell Bank on wave-lengths of 4 m. and 8 m. Similar results have been reported by Harrison[7] from the International Geophysical Year auroral studies at Halley Bay.

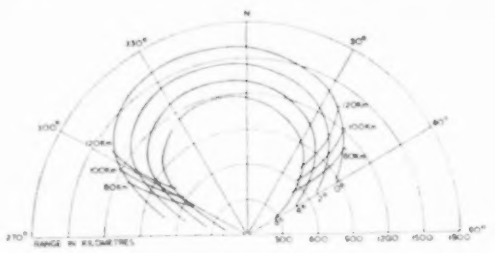


Fig. 2. Polar map for Bushy Hill, Essex, showing loci of feet of perpendiculars on the lines of force of the Earth's magnetic field

It is the high resolving power in both range and azimuth of the 1,300 Mc./s. radar equipment that has permitted the form of the aurora to be photographed with the precision shown in Fig. 1. The detail contained in this record allows the theory of radio reflexion from field-aligned regions of electron concentration to be tested and the stringency of the specular reflexion condition assessed in the case of a wave-length of 23 cm.

In Fig. 2 are shown the loci of the feet of the perpendiculars drawn from the radar site at Bushy Hill, Essex, to the lines of force of the Earth's field: each curve corresponds to a given angle of elevation of the rays from the radar. The magnetic data from which these curves have been calculated was taken from the Admiralty charts of isogonics and isoclinics (January 1960). Also included in Fig. 2 are the curves of constant height corrected for atmospheric refraction.

It will be seen that the area of Fig. 2 included between the 80 km. and 100 km. height curves and lying between the 0° and 6° elevation loci corresponds very closely indeed to the auroral arcs of Fig. 1. Now the beam-width of the radar in the horizontal plane is 0·7° while the angle subtended by a tangential element of the auroral arc at 1,000 km. is 5°. It is clear, therefore, that the azimuthal extent of the auroral form of Fig. 1 is not attributable to the beam-width of the radar. The azimuthal location of a height curve as plotted on Fig. 2 is quite sensitive to the height parameter and so a possible interpretation of Fig. 1 in the light of Fig. 2 would be that the auroral reflexions commence in the region of the 80-km. level of the ionosphere and extend upwards to an approximate height of 105 km. Alternatively, the azimuthal spread of the auroral arc could be regarded as arising from rays incident at angles between $90 \pm \frac{1}{2}°$ on the auroral columns of ionization located at a height of 90 km. It is probable that both the aspect and altitude effects play their parts in forming the auroral patterns of Fig. 1, but the present microwave experiments clearly show that the departure from the 90° reflexion condition is less than $\pm \frac{1}{2}°$, and that the region of the ionosphere where the auroral reflexions take place is of the order of 20 km. thick.

The mean height of the auroral layer as deduced from Fig. 1 by measurement of the azimuthal spread of the two auroral arcs, that is, 90 km., is lower than the value suggested by other workers operating at much lower radio frequencies. The evidence given above suggests that an auroral disturbance of sufficient intensity to be observed at 1,300 Mc./s. will only occur as an aftermath of a very vigorous solar upheaval and in association with extreme magnetic storms. In these circumstances it might be expected

that the solar emission would contain a proportion of more energetic primary particles capable of producing ionization at lower levels of the ionosphere and also of yielding auroral displays at lower latitudes. This southward movement of the aurora during the growth of intense magnetic storms has been discussed by Störmer[8] and has received confirmation in recent International Geophysical Year work[9]. It will be noted, however, that the kinetic energy of the solar particles at the moment of penetration into the Earth's atmosphere, if taken as that corresponding to the average velocity of transit from the Sun to the Earth, that is, 1,133 km./sec. as given above, would scarcely seem adequate to produce the observed microwave auroral effects at so low an altitude as 80–100 km.; it is probable that account must also be taken of the flux density of the incident particles.

The fact that the aurora of Fig. 1 was not observed in a northerly direction from the radar is a consequence of the shape of the vertical radiation diagram of the aerial, which extends from 0·2° to 6°, these elevations corresponding to 10 decibels of power reduction relative to that of the lobe maximum located at 1·6°. This figure of 1·6°, when associated with the observed range of 1,000 km. for the position of the echo of maximum amplitude, gives a height of 98 km. for this particular reflexion point.

The signal/noise ratio measured for this echo was 1·3/1; since the receiver noise-level was $4 \times 10^{-15}$ watt, it may be deduced that the equivalent radar cross-section of a region of the aurora which yields a single pulse point on the plan position indicator is 1·4 sq. m. By making reasonable assumptions as to the volume of the ionosphere contributing to this signal the echoing area per unit volume of the auroral scattering region may be estimated as of the order of $10^{-9}$ m.$^{-1}$.

If incoherent scattering by electrons is responsible for this reflexion of microwave energy, then, taking the Thomson cross-section of a single electron as of the order of $10^{-30}$ m.$^2$ would lead to a density of electrons of $10^{14}$ per c.c. On the other hand the electron density corresponding to normal critical reflexion for a frequency of 1,300 Mc./s. would be $2 \times 10^{10}$ electrons per c.c. It seems clear that neither of these mechanisms can be responsible for the aurora observed at 1,306 Mc./s. and that a theory of scattering such as has been developed by Booker (*loc. cit.*) must be applied.

We wish to thank our colleagues of the Radar and Photographic Groups for their assistance with the observational programme and the Director of Eskdalemuir Observatory for supplying the magnetic data.

[1] Chapman, S., *J. Atmos. Terr. Phys.*, **3**, 1 (1952).
[2] Booker, H. G., *J. Atmos. Terr. Phys.*, **8**, 204 (1956).
[3] Booker, H. G., "Physics of the Upper Atmosphere", ed. Ratcliffe, J. A. (Academic Press, London, 1960).
[4] Fricker, S. J., Ingalls, R. P., Stone, M. L., and Wang, S. C., *J. Geophys. Res.*, **62**, 527 (1957).
[5] Peterson, A. M., Villard, O. G., Leadabrand, R. L., and Gallagher, P. B., *J. Geophys. Res.*, **60**, 497 (1955).
[6] Watkins, C. D., *J. Atmos. Terr. Phys.*, **19**, 1 (1960).
[7] Harrison, D. P., *Proc. Roy. Soc.*, A, **256**, 229 (1960).
[8] Störmer, C., "The Polar Aurora" (Oxford, 1955).
[9] Obayashi, T., and Hakura, Y., "Report of Ionosphere Research in Japan", **14**, 1 (1960).

# A VERSATILE METHOD FOR SHORT-TERM SPECTRUM ANALYSIS IN 'REAL-TIME'

By J. S. GILL
Joint Speech Research Unit, Eastcote, Middlesex

THE variations with time of the short-term energy spectrum of signals such as speech, music, singing, etc., can be measured with a bank of electrical band-pass filters and rectifiers. This leads to the type of display in three dimensions (time, frequency, intensity) commonly known as a sound spectrogram. Spectrographic patterns have proved of great value in the study of complicated audio frequency signals, especially human speech. However, this method becomes impractical when large numbers of filters are required. For example, at least 160 filters would be needed to provide a reasonable display when analysing a band 4 kc./s. wide with filters 50 c./s. wide. A choice of analysis band-width is also often required, and this is particularly difficult to arrange on a large filter-bank.

The analysis can be performed in a much more economical and flexible manner by recording the signal and then analysing by repeatedly playing this recording through a single filter. The signal is swept slowly across the pass-band of this filter by means of a frequency-changing process[1]. (Any filter 'remembers' its immediate past history, and so it is not possible to analyse merely by sweeping the single filter rapidly across the frequency band occupied by the original signal[2].) The output of this filter is recorded on a surface, usually a sheet of electro-sensitive paper, which rotates synchronously with the recorded signal, thus producing a sound spectrogram. The time required for a complete analysis is at least:

$$T = t + \frac{Nt}{k}$$

where $T$ = total time required, $t$ = original duration of recorded signal, $N$ = required number of separate analyses, $k$ = play-back speed/recording speed. In most existing instruments of this type $T/t$ is about 100.

There are many calls, particularly in the study of speech, for a versatile spectrum analyser the output of which unfolds as the speech proceeds in time, that is, operates in 'real-time'. Although a filter-bank can be used for this purpose, detailed analysis by this method is rather impractical, due to the large number of filters that are needed. The single filter method outlined above cannot provide 'real-time' operation, however large $k$ may be, because recording and analysis do not proceed simultaneously. In the method to be described these two processes of recording and analysis are interleaved, as shown in Fig. 1, to enable a single analysis filter to be used for determination, in 'real-time', of the short-term spectral properties of a signal.

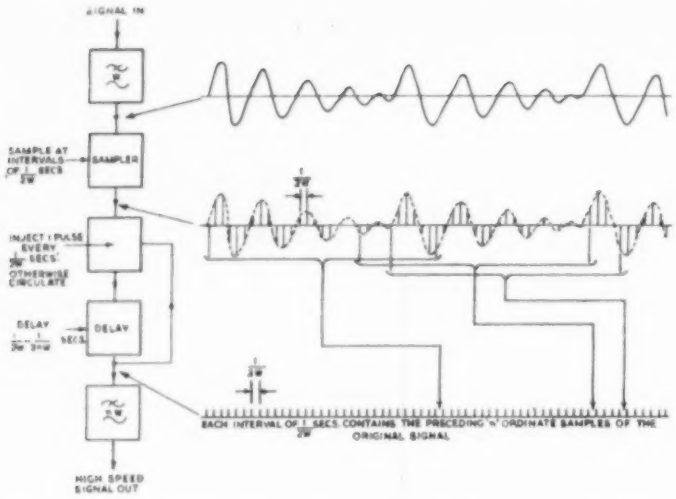

SIGNAL IN
SAMPLE AT INTERVALS OF 1/2W SECS
SAMPLER
INJECT 1 PASS EVERY 1/2W SECS OTHERWISE CIRCULATE
DELAY 1/2W - 1/2nW SECS
DELAY
EACH INTERVAL OF 1/2W SECS CONTAINS THE PRECEDING n ORDINATE SAMPLES OF THE ORIGINAL SIGNAL
HIGH SPEED SIGNAL OUT

Fig. 1. High-speed repetition of the immediate past of a signal by means of a circulating store

The signal to be analysed is restricted to the frequency band $O$–$W$ c./s. and ordinate samples taken at $1/2W$ sec. intervals are injected into a circulating memory of length $1/2W$–$1/2nW$ sec. which always contains the last $n$–1 signal samples. These samples are now spaced at $1/2nW$ sec. intervals, and during each $1/2W$ sec. interval the entire contents of the memory, namely, the past $n/2W$ sec. of the original signal, circulate at $n$ times their original rate. Each ordinate sample is available during $n$ successive circulations and can therefore contribute to $n$ separate analyses, which are performed by a single analysis filter preceded by a frequency-changer.

The high-speed signal fed to this filter has discontinuities at intervals at $1/2W$ sec. The effects of these must be excluded from, or at least minimized in, the final display. This is possible provided that the majority of the impulse response of the analysis filter is contained within $1/4W$ sec. These unwanted transients can then be suppressed by inhibiting the analysis filter output during the appropriate half of each $1/2W$ sec. interval. The frequency-time plane is mapped as a sequence of strips, each of effective length $n/4W$ sec. The actual time required for each strip is $1/2W$ sec., and so it is possible to produce a spectrographic display comparable to that provided by a parallel filter-bank of $n/2$ filters.

It has been shown that a gaussian shape of filter characteristic gives the smallest uncertainty product[3] (time resolution × frequency resolution) and so this characteristic was chosen for the analysis process. The impulse response of such a filter is not of finite duration, and so the effects of the $1/2W$ spaced transients cannot be completely suppressed. In practice the analyser output is inhibited during the intervals in which these disturbances exceed one-tenth of their maximum amplitude. The requirements for the circulating memory are, for an idealized gaussian filter:

$$ft \simeq 1{\cdot}14$$

where $f$ = bandwidth at the $\frac{1}{2}$ power points, $t$ = duration of impulse response at a tenth of maximum amplitude. So the unwanted transients can be suppressed and the frequency-time plane mapped when:

$$\frac{1}{2} \times \frac{1}{2W} > \frac{1}{2nW\tau} > \frac{1{\cdot}14}{f}$$

where $\tau$ = digit spacing within the memory. Hence, $\tau < f/9W^2$.

A magnetic or dielectric drum can be used for storage when the sampling-rate (and hence the required rate of rotation) is fairly low—say, less than 500 per sec. No wholly analogue method has yet been found that is suitable for storage and high-speed repetition of wider band-width signals such as speech. For this purpose the only satisfactory solution, at

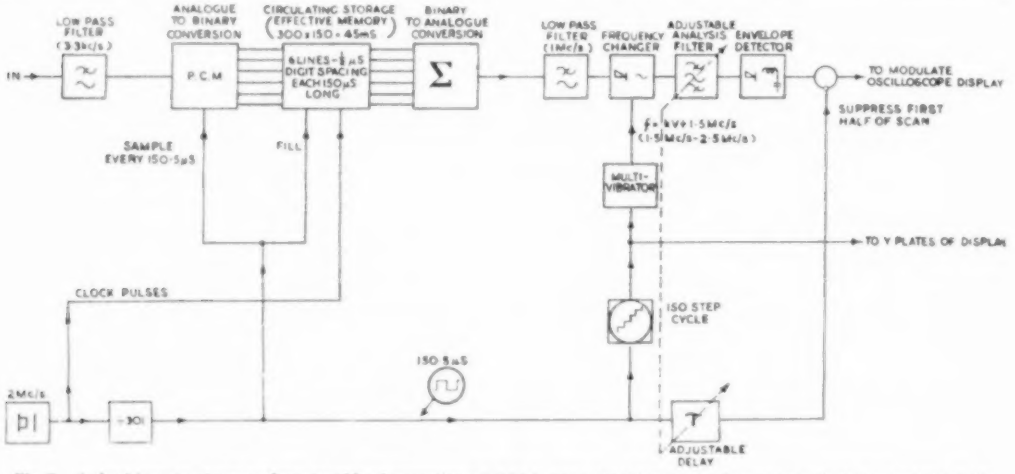



Fig. 2. A short-term spectrum analyser capable of processing a 3·3 kc./s. wide signal band in 'real-time' at analysis band-widths (half-power) down to 47 c./s.

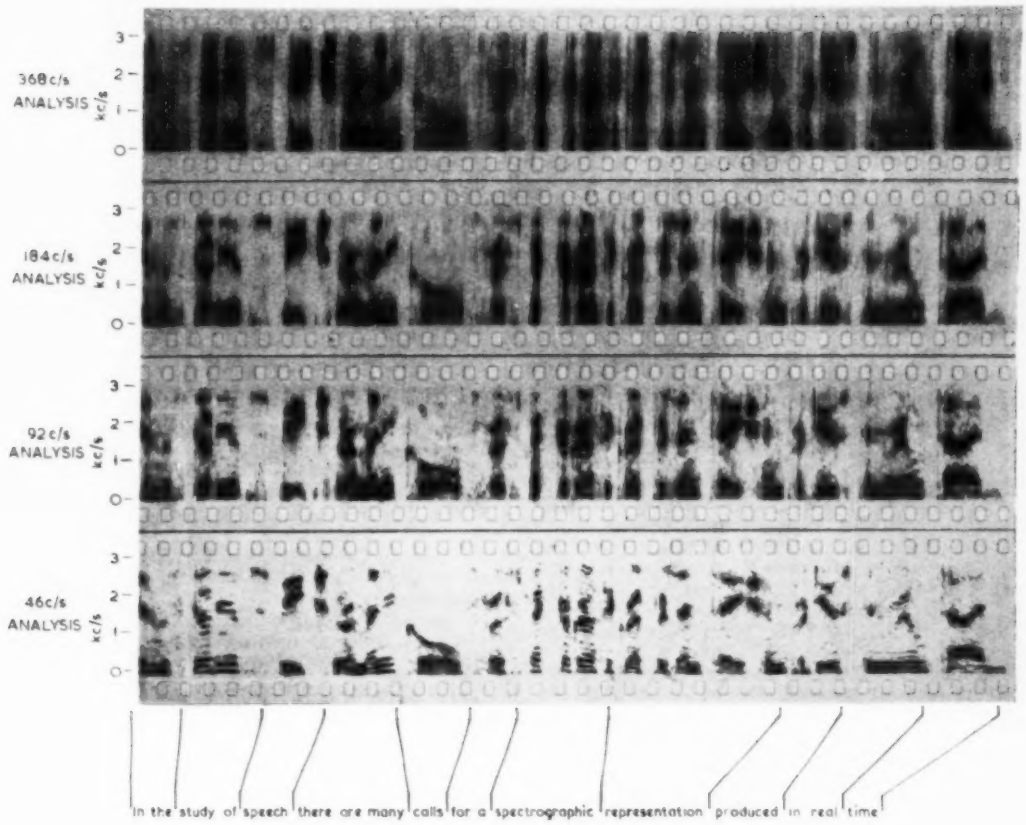



Fig. 3. Continuous spectrograms produced by the analyser shown on Fig. 2

present, is to express each ordinate sample as a set of $n$ binary digits (that is, digitally encode the signal by means of pulse code modulation) and to store and repeat the signal in this binary form.

'Real-time' spectrum analysis of a 3·3 kc./s. wide band at analysis band-widths down to about 50 c./s. has been achieved by the method outlined in Fig. 2. The signal is sampled at 150·5-μsec. intervals and encoded into 6 binary digits/sample by a pulse code modulator, the output of which takes the form of six streams of binary digits. Each one of these streams feeds its own circulating store into which these digits are packed at $\frac{1}{2}$ μsec. spacing. The stores consist of magnetostrictive-acoustical delay lines of length 150 μsec. which use wire for the delay medium[4]. The six high-speed streams are decoded into a sequence of high-speed replicas of the immediate past 45 m.sec. of the signal, which are presented for analysis at 300 times their original rate. This high-speed signal is stepped at 150·5 μsec. intervals across the pass-band of a fixed analysis filter and the resulting display is of the form shown in Fig. 3.

The useful dynamic range of the analysis cannot, at any time, exceed that of the orginal binary digital encoder. In general, the range will be somewhat less than this and dependent on the structure of the signal. The appearance of the spectrograms shown on Fig. 3, which were produced by this continuous analyser, suggests that six bits/sample is probably sufficient for most work on speech. If necessary, the dynamic range can be increased by digitally encoding the original signal into a larger number of bits/sample.

This new instrument provides, for the first time, a continuous analysis of resolution sufficient to show both the gross spectral envelope of the speech (determined by the resonances of the vocal tract) and the fine detail associated with the exciting source (for example, the harmonic structure that characterizes the pitch of voiced sounds). This may materially assist work on voice training and speech correction[5]. The method can provide a suitable basis for excitation and system function[6] estimation in analysis–synthesis systems of telephony. Other more speculative applications such as phonetic transcription[7,8] and sound coding can be visualized.

I wish to thank Dr. J. Swaffield, head of the Joint Speech Research Unit, for his support and encouragement, P. F. Leach for much of the detailed design and D. Calvert for construction of the instrument.

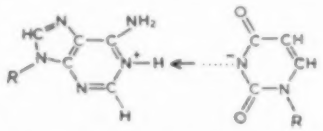
[1] Koenig, K., Dunn, H. K., and Lacy, L. Y., *J. Acous. Soc. Amer.*, **18**, No. 1, 19 (1946).
[2] Barber, N. F., *Electronic Engineering*, No. 225 (1949).
[3] Gabor, D., *J. Inst. Elec. Eng.*, **93**, Part 3, 435 (1946).
[4] Scarrott, G. G., and Naylor, R., *J. Inst. Elec. Eng.*, **103**, B, Supp. No. 3, 497 (1956).
[5] Potter, R. K., Kopp, G. A., and Green, H. C., "Visible Speech" (D. Van Nostrand Inc., 1947).
[6] Huggins, W. H., *J. Acous. Soc. Amer.*, **22**, No. 6, 765 (1950).
[7] Fry, D. B., *J. Brit. Inst. Rad. Eng.*, **19**, No. 4, 211 (1959).
[8] Denes, P., *J. Brit. Inst. Rad. Eng.*, **19**, No. 4, 219 (1959).

# NUCLEIC ACIDS IN DEUTERIUM OXIDE SOLUTION

By Y. KYOGOKU, M. TSUBOI and T. SHIMANOUCHI
Department of Chemistry, University of Tokyo
AND
I. WATANABE
Institute for Virus Research, University of Kyoto

## An Infra-red Criterion of the Base Pairing in Nucleic Acid Structure

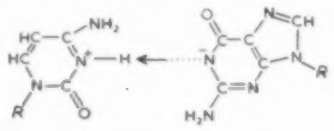
IN the course of work on the infra-red spectra of nucleosides[1], we have found that, from a 1-mole : 1-mole aqueous mixture of adenosine and uridine, a complex crystal is obtainable, the 6μ-region spectrum of which is greatly different from the sum of the spectra of the adenosine and uridine crystals (Fig. 1, *A*). In the spectrum of the complex crystal a strong band is observed at 1,700 cm.$^{-1}$ which is not observed in the adenosine spectrum or in the uridine spectrum. In the spectrum of adenosine hydrochloride, a strong band is observed at 1,693 cm.$^{-1}$ (not far from 1,700 cm.$^{-1}$), which is attributable[1] to a stretching vibration of the C = N bonds of the purine ring where the π-electrons are localized at the C = N bonds to a greater extent than in the purine ring of free adenosine. These facts are explained by considering that there is a base–base interaction between the adenine and uracil residues in the complex crystal, and that in this interaction there takes place a proton transfer from the uracil residue to the adenine residue such as :



(1)

which causes a π-electron localization[1] in the C = N bonds of the adenine residue, giving rise to the strong band at 1,700 cm.$^{-1}$.

From a 1-mole : 1-mole mixture of aqueous solutions of cytidine and guanosine, a complex crystal was obtained which gives a strong band at 1,720 cm.$^{-1}$ (see Fig. 1, *B*). Neither in the spectrum of cytidine crystal nor in that of guanosine crystal are strong bands observed in the vicinity of 1,720 cm.$^{-1}$, but in the spectrum of cytidine hydrochloride crystal a strong band is observed at 1,725 cm.$^{-1}$. The latter band can be assigned to the stretching vibration of the C=O bond of the cytosine residue which has acquired a proton. Therefore, the 1,720 cm.$^{-1}$ band of the cytidine–guanosine complex is attributable to a proton-transferred structure :



(2)

which may be formed by the base-base interaction of the two nucleosides.

Similar strong bands at about 1,710 cm.$^{-1}$ are observed for the complex of cytidine and uridine and for that of adenosine and guanosine, but not for the complex of adenosine and cytidine nor for that of guanosine and uridine[1].

All the above facts suggest that the specific pairings of cytosine–guanine and adenine–uracil generally postulated in nucleic acid structures[2] involve proton transfer from uracil or guanine to adenine or cytosine, and that such pairings cause strong absorptions in the vicinity of 1,710 cm.$^{-1}$. Therefore, the appearance of the strong band at 1,710 cm.$^{-1}$ may be used as a criterion of the existence of the specific base-pairing.

We have observed 6μ-region spectra of some nucleic acids and nucleoproteins in their solid films[3]. Some of the results are given graphically in Fig. 2. The sodium salt of deoxyribonucleic acid from calf thymus placed in air of relative humidity 75 per cent shows a strong band at 1,708 cm.$^{-1}$, but in dry air a much weaker band here. This fact may be taken as indicating that the specific base–base

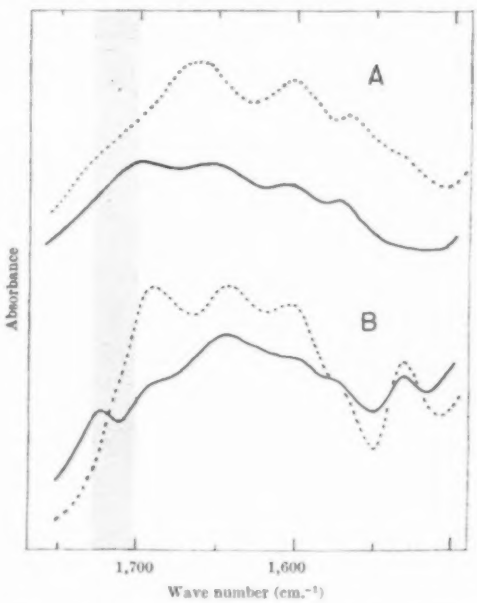



Fig. 1. *A*, infra-red spectrum of a complex (1 mole : 1 mole) of adenosine and uridine (——), and the sum of the spectra of adenosine and uridine (– – –); *B*, infra-red spectrum of a complex (1 mole : 1 mole) of cytidine and guanosine (——), and the sum of the spectra of cytidine and guanosine (– – –)

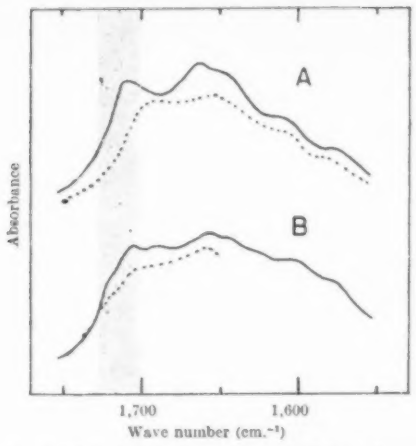



Fig. 2. *A*, Infra-red spectra of sodium salt of deoxyribonucleic acid film (from calf thymus) in air of relative humidity 75 per cent (——), and of the same film in dry air (– – –); *B*, infra-red spectra of a native sodium salt of ribonucleic acid film from microsomal particles of *E. coli* (——), and a film obtained from a solution of the sodium salt of ribonucleic acid heated at 100° C. for 10 min. (– – –). Both are observed at 75 per cent relative humidity

interaction is much weaker in the dry film than in the wet film. This is in accordance with what was concluded from other evidence[4,5]. The sodium salt of ribonucleic acid prepared from *E. coli* microsomal particles by the phenol method shows a moderately strong band at 1,705 cm.$^{-1}$ both in its dry and wet states. When it is heated at 100° C. for 10 min. or treated with ribonuclease, however, the 1,705-cm.$^{-1}$ band is observed with much weaker intensity, just as is expected.

A strong band appears at 1,710 cm.$^{-1}$ for the sodium salt of nucleohistone (deoxyribonucleic acid–histone) from calf thymus. This fact may be interpreted as indicating that there are numerous base pairings in deoxyribonucleic acid–histone, in accordance with the result of X-ray work[6]. For some samples of magnesium salt of microsomal particles from rat liver[7], only a weak band is observed at about 1,710 cm.$^{-1}$. This may indicate that, in such microsomal particles, a part of the base residues is bound to the protein and not available for the base–base interaction.

We have observed 6$\mu$-region spectra of various nucleic acids and nucleoproteins, not only in their solid films but also in their deuterium oxide solutions. Results of these observations and the interpretations on the basis of the criterion suggested here will be given in detail elsewhere.

We wish to express our thanks to Dr. M. Takanami for his kindness in supplying rat liver microsomal particles. This work was aided in part by a grant from the Scientific Research Fund of the Ministry of Education of Japan.

## Parallelism of the Hypochromicity at 260 m$\mu$ and the Hyperchromicity at 1,685 cm.$^{-1}$ of Nucleic Acids in Deuterium Oxide Solution

In a previous communication[8], it was shown that the absorption band at about 1,685 cm.$^{-1}$ of nucleic acids (deoxyribonucleic and ribonucleic acids) in deuterium oxide solutions is attributable to the base residues which are involved in the specific base–base pairings. In order to obtain further information of the nature of this 1,685-cm.$^{-1}$ band, we have observed the 6$\mu$-region spectra of deoxyribonucleic acid and ribonucleic acid in their deuterium oxide solutions at various temperatures.

Some of the results obtained are shown in Fig. 3. Here, the samples used are the sodium salt of calf thymus deoxyribonucleic acid and the sodium salt of ribonucleic acid from rat liver microsomal particles. These are dissolved (5–10 per cent) in a deuterium oxide solution which is 0·1 molar in potassium chloride. The deoxyribonucleic acid solution was heated to 93° C., and the ribonucleic acid solution to 70° C. After they were kept at these temperatures for 1–2 min., they were cooled and the spectral changes were examined for reversibility. As is seen in Fig. 3, the most conspicuous spectral change that occurs with the change of temperature of the solution is that of relative intensity of the 1,685 cm.$^{-1}$ band.

In Fig. 4, the reciprocal of the intensity of the 1,685 cm.$^{-1}$ band relative to that of the 1,665 cm.$^{-1}$ band is plotted against the temperature of the solution. In the deoxyribonucleic acid solution there is a sharp change (transition) at about 85° C., while in the ribonucleic acid solution the change occurs gradually from 30° C. to 70° C. The 'cooling curve' lies always somewhat higher than the 'heating curve'. This trend is more evident when the maximum temperature reached is higher or when the solution is

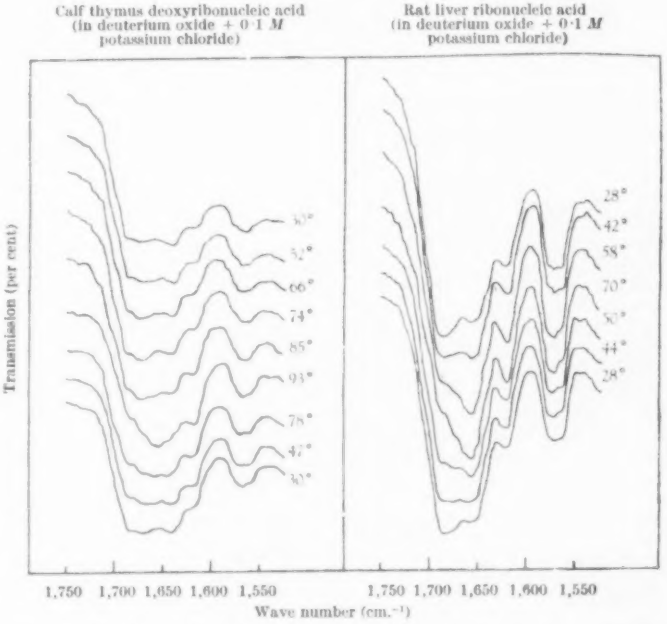



Fig. 3. Infra-red absorption spectra of deoxyribonucleic and ribonucleic acids in deuterium oxide solutions at various temperatures

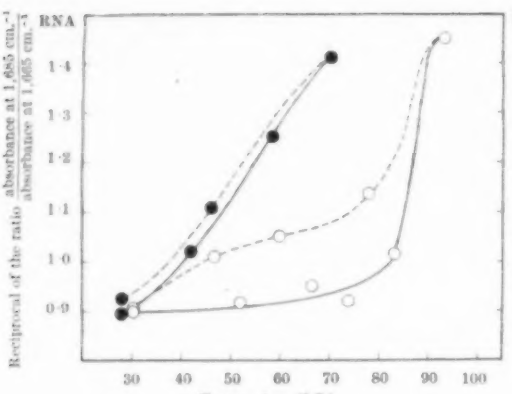



Fig. 4. The variation in the reciprocal of the relative intensity of the 1,685 cm.$^{-1}$ band as a function of temperature of the solution. — o —, Heating curve of deoxyribonucleic acid; – – o – –, cooling curve of deoxyribonucleic acid; — ● —, heating curve of ribonucleic acid; – – ● – –, cooling curve of ribonucleic acid

kept at the maximum temperature for a longer period.

All these features of the curves of reciprocal intensity at 1,685 cm.$^{-1}$ versus temperature of the solution are very similar to those of the corresponding curves of optical density at 260 mμ versus temperature of the solution given by Marmur and Doty[9] and by Doty, Boedtker, Fresco, Haselkorn and Litt[10]. Therefore, it is very probable that the change in the electronic structures of the base residues that causes the 1,685 cm.$^{-1}$ band (1,710 cm.$^{-1}$ band of the undeuterated base residues (preceding communication)) is directly correlated with the hypochromicity at 260 mμ.

We have also examined the relative intensity of the 1,685 cm.$^{-1}$ band at various temperatures of the yeast-soluble ribonucleic acid with sedimentation constant 4 Svedberg units. The reciprocal intensity–temperature profile of the soluble ribonucleic acid was found to be practically the same as that of rat liver microsomal ribonucleic acid in spite of the great difference in their molecular weights.

We wish to express our thanks to Dr. M. Takanami for the sample of rat liver microsomal ribonucleic acid and to Dr. S. Osawa for the sample of yeast-soluble ribonucleic acid. The expense of this research has been partly defrayed from grant-in-aid for scientific research from the Ministry of Education of Japan.

[1] Kyogoku, Y., Tsuboi, M., and Shimanouchi, T., Abst. Thirteenth Annual Meeting Chem. Soc. Japan, 239 (April 1960). Details of our experiments on nucleosides will be published elsewhere.
[2] Watson, J. D., and Crick, F. H. C., *Nature*, **171**, 737 (1953).
[3] Watanabe, I., Shimanouchi, T., Tsuboi, M., Kyogoku, Y., and Takanami, M., Abst. Symp. on Protein Structure, Chem. Soc. Japan, Osaka, 3 (October 1959). Details of our experimental results for ribonucleic acid and microsomal particles under various conditions will be published elsewhere.
[4] Franklin, R. E., and Gosling, R. G., *Acta Cryst.*, **6**, 673 (1953).
[5] Sutherland, G. B. B. M., and Tsuboi, M., *Proc. Roy. Soc.*, A, **239**, 446 (1957).
[6] Wilkins, M. H. F., Zubay, G., and Wilson, H. R., *J. Mol. Biol.*, **1**, 179 (1959).
[7] Takanami, M., *Biochim. Biophys. Acta*, **39**, 318 (1960).
[8] Shimanouchi, T., Tsuboi, M., Kyogoku, Y., and Watanabe, I., *Biochim. Biophys. Acta*, **45**, 195 (1960).
[9] Marmur, J., and Doty, P., *Nature*, **183**, 1427 (1959).
[10] Doty, P., Boedtker, H., Fresco, J. R., Haselkorn, R., and Litt, M., *Proc. U.S. Nat. Acad. Sci.*, **45**, 482 (1958).

# GRADIENT OF CHOLINESTERASE ACTIVITY AND OF CHOLINE ACETYLASE ACTIVITY IN NERVE FIBRES

## Gradient of Cholinesterase Activity

THERE are many indications that cholinesterase is synthesized in the cell bodies of neurons and carried down the axons towards the nerve endings (cf. Hebb[1]). The mechanism of the transport is unknown. It seems that information concerning the fate of the enzyme along the axonal path at various distances from the cell bodies and end organs might serve as one of the preliminary steps towards elucidation of this problem.

The nerves used for this kind of investigation should fulfil the following requirements: (1) the nerve trunk should be unbranched, so that at any level of the nerve all fibres are approximately equidistant from their terminal organs; (2) it should be long enough to permit determinations of cholinesterase activity at several levels of the nerve.

The phrenic nerve of the dog satisfies approximately these conditions. The thin fascicles innervating intrathoric organs are easily separated from the main bundle to the diaphragm. The amount of protein per unit length was found to be the same at all levels of this bundle. The phrenic nerve has the additional advantage of being one of the most regularly discharging muscle nerves of the body. The regular alternation of periods of activity and of rest is likely to lead to a steady state between synthesis and utilization and, consequently, to constant amounts of enzyme at any given level of the nerve.

The phrenic nerves used were some 200–300 mm. long from the exit from the vertebral column to the level of branching near the diaphragm. They were removed from living anæsthetized animals, divided into three parts and cleaned of epineurium under the dissecting microscope.

Cholinesterase activity was determined by an ultra-microtitrimetric method of W. Niemierko (personal communication). Acetylthiocholine iodate was used as substrate, following McOsker and Daniel[2], and no separate determinations of true and pseudo-cholinesterase have been made so far. About 12 mgm. of fresh tissue were necessary for each determination, consisting of two parallel runs and one blank.

There are considerable differences in cholinesterase activity in various animals, and differences up to 30 per cent between the right and left nerve of the same animal.

Table 1 shows the cholinesterase activity in thirteen normal phrenic nerves at the upper, middle and low levels. In all nerves activity was slightly higher at the upper than at the lower level, and, in most cases, the middle level presented intermediary values. The differences between high and middle,

Table 1. Cholinesterase Activity at Three Levels of the Phrenic Nerve

Amount of acetylthiocholine split by 10 mgm. of fresh tissue in 2 hr. at 37° C., expressed in $\mu$l. of 0·1 $M$ solution of the substrate

| Dog | Upper | Middle | Lower |
|---|---|---|---|
| *P.*15—left | 5·54 | 5·72 | 4·22 |
| *P.*15—right | 6·17 | 5·95 | 5·32 |
| *P.*17—left | 3·15 | 3·50 | 2·88 |
| *P.*17—right | 4·37 | 3·64 | 3·98 |
| *P.*18—left | 5·92 | 5·31 | 5·69 |
| *P.*18—right | 6·11 | 5·31 | 4·93 |
| *P.* 1—left | 4·39 | 4·15 | 3·15 |
| *P.* 1—right | 4·12 | 3·41 | 3·06 |
| *P.* 2—left | 4·12 | 3·45 | 2·82 |
| *P.* 2—right | 5·07 | 4·05 | 4·15 |
| *P.* 9—right | 5·14 | 5·28 | 4·62 |
| *P.*10—right | 7·08 | 6·68 | 6·71 |
| *P.*19—right | 6·38 | 5·62 | 5·31 |
| Mean | 5·20 | 4·77 | 4·37 |
| Percentage of the lower level | 119 | 109 | 100 |

and between high and low levels, are significant ($t$-test) at $P > 0{\cdot}99$. The difference between the middle and low levels is significant at $P > 0{\cdot}95$.

After section of the nerve, the amounts of cholinesterase and of choline acetylase[4] increase above the site of lesion. This increase is attributed by Hebb to the accumulation of the enzyme carried down from the perikaryon and prevented by the lesion from further displacement towards the periphery.

It was interesting, therefore, to see how the normal distribution of cholinesterase throughout the length of the nerve is altered after nerve section. This was done in the following experiments. Under aseptic conditions, the phrenic nerve near the diaphragm was sectioned and a portion of it removed and analysed for cholinesterase activity. The value obtained served to estimate the normal cholinesterase content of the nerve investigated at its low level. Then, after various time-intervals, the rest of the nerve was removed and cholinesterase determined at three levels of the proximal stump. The result of two experiments, 4 and 7 days after section, are shown in Fig. 1. The activity of the normal nerve was determined at the low level only; the probable normal values at higher levels are taken from percentages of Table 1. The results show that the increase of cholinesterase activity immediately above the site of section is accompanied, initially, by depletion of enzyme in the more proximal parts of the nerve.

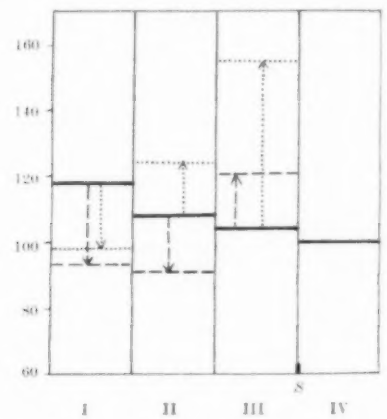



Fig 1. Changes of cholinesterase activity after section of the nerve at various levels of the proximal stump. I, II, III, IV represent portions of the nerve, the most proximal at the left. *S*, site of section. Ordinates: cholinesterase activity, as a percentage of that of the lowest part of normal nerve. Heavy line, normal nerve; broken line, 4 days after section; dotted line, 7 days after section

It should be noted that the phrenic is a very thin nerve and therefore rather long segments, of 60–100 mm., had to be taken in order to get enough tissue for determination of cholinesterase. In places where the differences of activity are likely to vary abruptly, as in the terminal part above the site of lesion, the use of long segments will tend to smooth out the real differences. A thick nerve, in which much shorter segments could be used, would therefore be more useful for exact determination of spatial re-distribution of the cholinesterase above the site of section, as was done by Hebb and Silver for choline acetylase (see following communication).

The re-distribution of cholinesterase activity in a sectioned nerve seems to indicate, besides the piling-up of the enzyme above the section, a slowing down of enzyme production by the perikarya in the initial period examined here. These results are in keeping with those of Schwarzacher[5] and Chacko and Cerf[6], who observed by histochemical methods a decrease of cholinesterase in perikarya during axon reaction, and they may be correlated with functional changes in respiratory discharge after section of the phrenic nerve described by Acheson, Lee and Morrison[7]. It should be noted that preliminary experiments in which the phrenic nerve was cut at the cervical level have failed to produce an increase of cholinesterase activity above the site of lesion.

As a result of these experiments, we conclude that, in the unbranched trunk of the phrenic nerve, there is a proximo-distal gradient of cholinesterase activity, the activity of the most proximal part exceeding by some 20 per cent that of the distal part of the nerve. Such proximal excess would suggest that the cholinesterase is metabolized not only at the nerve endings but also in the axon, although it does not constitute a direct proof of such utilization.

The changes of distribution of cholinesterase along the nerve after section seem to indicate that the transport of the enzyme stored in the nerve continues to be peripheral even at the time when its production in the cell bodies is slowed down or abolished.

L. Lubińska

Department of Neurophysiology,

S. Niemierko

B. Oberfeld

Department of Biochemistry,
Nencki Institute of Experimental Biology,
Warsaw.

[1] Hebb, C. O., *Physiol. Rev.*, **37**, 196 (1957).
[2] McIsaac, D. E., and Daniel, L., *Arch. Biochem. Biophys.*, **79**, 1 (1959).
[3] Sawyer, C. H., *Amer. J. Physiol.*, **146**, 246 (1946).
[4] Hebb, C. O., and Waites, G. M. H., *J. Physiol.*, **132**, 667 (1956).
[5] Schwarzacher, H. G., *Acta Anat.*, **32**, 51 (1958).
[6] Chacko, L. W., and Cerf, J. A., *J. Anat.*, **94**, 74 (1960).
[7] Acheson, G. H., Lee, E. S., and Morrison, R. S., *J. Neurophysiol.*, **5**, 269 (1942).

## Gradient of Choline Acetylase Activity

It was shown earlier[1], that after section of a cholinergic nerve (the cervical sympathetic of the sheep) choline acetylase rises much above the normal concentration in the proximal trunk while, coincidentally, it falls steeply in the distal trunk. Unlike

true cholinesterase[2], lipolytic esterase[3] and substance *P* (ref. 4) which behave somewhat similarly, choline acetylase eventually disappears completely from the degenerating distal portion of the nerve. This has been regarded as evidence that all the axonal acetylase is derived from the perikaryon, whereas the other substances such as cholinesterase which do not disappear completely may be derived in part from extra-neuronal elements[5]. The increase of choline acetylase proximally fits in with the view that it is manufactured in the cell body, for, on the hypothesis that in the normal nerve the enzyme is moving steadily distally, section of the nerve would interrupt its progress and cause it to accumulate at that point. However, although it may be accepted that there is a flow or movement of materials from cell to periphery, a concept first formally stated by Weiss and Hiscoe[6] and supported by experiments with isotopically labelled compounds[7], it is by no means clear how the movement takes place.

The simplest idea is that there is a flow of dissolved axoplasmic constituents; but experiments in this laboratory[8] have shown that most of the axonal choline acetylase is firmly bound to structural elements; and these we believe to be part of the system of membranes that is continuous with the endoplasmic reticulum in the cell body. Thus, transport of the enzyme would appear to depend on movement of some part of the structural framework of the axon, possibly the growth of the whole axon. To some extent the experiments reported here support this view.

In these experiments the sciatic nerve of the goat was sectioned approximately 5 cm. below the fusion of its constituent spinal roots. It was established initially that the rise in choline acetylase in the proximal stump reached a maximum 5–7 days after operation. It was also found that the rise, estimated by comparison with the corresponding contralateral nerve, was entirely confined to the nerve trunk, there being no significant difference in enzyme concentration in either the motor or the mixed spinal roots of the nerve on the two sides. At these more central levels, the concentration on the side of operation was always within 20 per cent of the controls, a variation which is within the overall experimental error of the method of the assay for choline acetylase.

The finding that the rise was limited to the nerve trunk led us to investigate the gradient of activity in the region of the nerve immediately above the section. For this purpose the proximal part of the sectioned nerve was divided into five portions, 1 or 1·5 cm. in length; each portion was analysed separately and then compared with the corresponding piece of nerve from the contralateral sciatic. Choline acetylase activity in each was expressed in terms of the unit length of nerve, since variations in protein and water content of the operated nerve might obscure changes in the enzyme concentration if this were expressed in terms of weight of tissue.

From the results given in Table 1, it is clear that the rise in enzyme 7 days after operation is confined to the terminal 3 cm. of nerve. In fact, it is probable that it is confined to an even shorter length of nerve, since the region immediately above the section always contained some damaged nerve tissue. Similarly, the length between 2 and 3 cm. (called *P*3 in Table 1) may extend beyond the area of increased enzyme activity. We therefore estimate that at 7 days after operation the change is limited to about 2–2·5 cm.

Table 1. Change in Choline Acetylase in the Sciatic Nerve of the Goat 7 days after Nerve Section

| Proximal stump (segments numbered from the level of section) | Length (cm.) | Fresh wt. (mgm.) | Dry wt. (mgm.) | γACh/ cm./hr. | Per cent change in sectioned nerve |
|---|---|---|---|---|---|
| *P*1 Sectioned nerve | 1·0 | 327 | 34 | 147 | + 84 |
| *P*1 Control nerve | 1·0 | 158 | 35 | 80 | |
| *P*2 Sectioned nerve | 1·0 | 304 | 47 | 113 | + 117 |
| *P*2 Control nerve | 1·0 | 163 | 29 | 52 | |
| *P*3 Sectioned nerve | 1·0 | 227 | 51 | 122 | + 90 |
| *P*3 Control nerve | 1·0 | 131 | 31 | 64 | |
| *P*4 Sectioned nerve | 1·5 | 235 | 38 | 59 | No change |
| *P*4 Control nerve | 1·5 | 230 | 44 | 59 | |
| *P*5 Sectioned nerve | 1·5 | 233 | 45 | 58 | + 18 (less then signif.) |
| *P*5 Control nerve | 1·5 | 238 | 33 | 49 | |
| Distal stump | | | | | |
| *D*1 Sectioned nerve | 2·5 | 719 | 162 | 3 | − 94 |
| *D*1 Control nerve | 2·5 | 559 | 123 | 56 | |

of nerve immediately proximal to the level of damage or section. Since at 4 days the length of nerve affected is shorter, and since the rise in enzyme begins to subside after 7 days, it is a fair inference that the figures given represent the maximum length of nerve in which higher enzyme activity occurs.

These findings, which are in general agreement with those of Lubińska *et al.* (see preceding communication) on the cholinesterase gradient in the sectioned phrenic nerve of the dog, seem to dispose of any possibility that the accumulation of enzyme in the proximal part of a sectioned nerve depends on its free diffusion downwards, since it is difficult to see how such a process could produce so sharply localized an increase in enzyme activity. We can, however, suggest one situation in which free diffusion is compatible with a terminal increase in enzyme: that is, if there is an increase in the space into which protein can diffuse. It might, for example, be imagined that section of an individual axon would permit its expansion terminally as the growing tip reached out beyond the Schwann cell tube. Cajal[9] has shown that the neuroma typically consists in part at least of extensive growth of such exploratory nerve tips. Some curve back and some go forwards, together forming a brush-like growth. On such a hypothesis, however, it is difficult to account for the length of nerve involved. It is likely that at the most only a few millimetres are involved in this sprouting and in the ballooning and branching of axons which is also seen at this time[6].

It seems to us that the accumulation of enzyme we have described is more likely to be associated with the precocious formation of synaptic vesicles in the sectioned axons, as has been reported for sectioned frog sciatic nerves[10]. This is the kind of change that would escape detection by the light microscope, and might well involve much greater lengths of nerve than would the grosser changes described by Cajal and others. It is possible that what happens is that the severed axons undergo morphological changes which make them comparable to pre-synaptic terminals, a region where there is also relatively high choline acetylase activity. It may be that in terminals of a normal nerve, for example, at the motor end-plate or at the sympathetic ganglion cell, this relatively greater concentration of choline acetylase is due not only to branching of the axons but also to expansion of the membrane system which ultimately

gives rise to the synaptic vesicles, particles thought to contain both choline acetylase and its product acetylcholine[11]. We suggest, therefore, a similar branching and budding of membranes at the tips of severed axons.

CATHERINE O. HEBB
ANN SILVER

Agricultural Research Council Institute
of Animal Physiology,
Babraham, Cambridge.

[1] Hebb, C. O., and Waites, G., *J. Physiol.*, **132**, 667 (1956).
[2] Sawyer, C. H., *Amer. J. Physiol.*, **146**, 246 (1946).
[3] Lumsden, C. E., *Quart. J. Exp. Physiol.*, **37**, 45 (1952).
[4] Holton, P., *J. Physiol.*, **149**, 35*P* (1959).
[5] Hebb, C. O., *Physiol. Rev.*, **37**, 196 (1957).
[6] Weiss, P., and Hiscoe, H. B., *J. Exp. Zool.*, **107**, 315 (1948).
[7] Ochs, S., and Burger, E., *Amer. J. Physiol.*, **194**, 499 (1958).
[8] Hebb, C. O., Krause, M., and Silver, A., *J. Physiol.*, **148**, 69*P* (1959)
[9] Cajal, Ramon y, "Degeneration and Regeneration of the Nervous System" (Oxf. Univ. Press, London, 1928).
[10] van Harreeman, V. L., Anderson, E., and Reger, J. F., *Exp. Cell. Res.*, Supp. 5, 153 (1958).
[11] Hebb, C. O., and Whittaker, V. P., *J. Physiol.*, **142**, 187 (1958).

# GLYCEROL IN *MYCOPLASMA MYCOIDES*

## Unbalanced Growth of *Mycoplasma mycoides* caused by Glycerol Deficiency

*MYCOPLASMA MYCOIDES* var. *mycoides*, the agent of contagious bovine pleuropneumonia, requires glycerol as an essential nutrient[1]. The concentration required for maximum turbidity increases from about 5 μgm./ml. in static cultures to about 50 μgm./ml. in cultures rotated mechanically to give a moderate degree of aeration. Glycerol is rapidly oxidized by cell-suspensions, probably by a flavoprotein-catalysed oxidation of α-glycero-phosphate[2]. If this is a pathway which is essentially irreversible, then the need for exogenous glycerol for lipid synthesis would be readily explained. The observation that cultures undergo rapid lysis after a period of growth in media containing limiting concentrations of glycerol suggested that glycerol deficiency might cause unbalanced growth.

It has been found that when fully viable cells are incubated in medium lacking glycerol, but adequate with respect to all other nutrients, they die at a rate of about 80–90 per cent per generation time. There was an early increase, followed by a decrease, in turbidity; an early loss of streaming birefringence; and an increase in the viscosity of the cultures, suggesting that lysis had occurred. Profound morphological changes were evident in electron micrographs taken during the course of incubation. In the early stages the cells became enlarged, and many had shrunken appendages. Later, there was a great preponderance of flattened ghost-like forms, and only a few electron-dense elements probably representing the remaining viable cells. 'Glycerol-less death' is prevented if another essential nutrient (uracil) is omitted or if chloramphenicol is added, and the onset of the morphological changes is retarded by the omission of uracil.

The hypothesis derived from these observations is that glycerol is needed for the synthesis of some surface structure, and that this synthesis is more sensitive to glycerol deficiency than is the synthesis of the cytoplasm. The greater requirement for glycerol under aerobic growth conditions is due to the greater rate of oxidation and consequent loss of glycerophosphate for synthetic purposes.

A. W. RODWELL.

[1] Rodwell, A. W., *Ann. N.Y. Acad. Sci.*, **79**, 499 (1960).
[2] Rodwell, A. W., and Rodwell, E. Shirley, *Aust. J. Biol. Sci.*, **7**, 18 (1954).

## A Polyglycerophosphate Compound from *Mycoplasma mycoides*

SOME preliminary work on the incorporation of glycerol labelled with carbon-14 by *Mycoplasma mycoides* var. *mycoides* has been carried out. The cells were grown in a partly defined medium (see preceding communication) to which 5–20 μc. of DL-glycerol-1-$^{14}$C was added per 100 ml. The total glycerol concentration was 4–20 μgm. per ml. The cultures were harvested after the end of the logarithmic phase, when glycerol had become limiting and streaming birefringence had largely disappeared. At this stage there is extensive conversion to non-viable ghost-like forms[1]. The cultures were centrifuged at 35,000*g* and the pellets extracted without preliminary washing. Although the main energy substrate was glucose, most of the glycerol was catabolized to lactate, and in none of the experiments was more than 8 per cent of the added isotope recovered in the pellet. Small amounts of non-dialysable activity found in the supernatant were presumably derived from cells which had lysed. Most of the carbon-14 in the pellet was present in substances which yielded glycerol or glycerophosphate compounds on hydrolysis, but about 10 per cent entered the ribose of ribonucleic acid where it was greatly diluted with unlabelled carbon.

In the first experiments the pellet was extracted with cold trichloroacetic acid, aqueous ethanol, and wet ethanol–ether according to a procedure used successfully for tracer studies with *E. coli*[2]. An unexpectedly large fraction (40–60 per cent) of the carbon-14 incorporated was not extracted by this method. Even after subsequent extraction with 5 per cent (w/v) trichloroacetic acid at 100° for 30 min., which removes the nucleic acids quantitatively from *M. mycoides*, a large amount of radioactivity remained in the residue. Alkaline hydrolysis of the latter released most of the remainder (33 per cent of the total incorporated) in the form of acid-soluble compounds. These included free glycerol and glycerophosphate, but at least three other compounds were present.

The results in Table 1 refer to an experiment in which the labelled cells were suspended in distilled water, frozen and thawed three times and then centrifuged at 26,000*g* for 15 min. It was convenient to include this step because about 80 per cent of the ribonucleic acid enters the supernatant fraction

under these conditions. Only 9 per cent of the carbon-14 appeared in the supernatant, and nearly all this was accounted for as acid-soluble compounds and as ribonucleic acid ribose. After extraction with cold trichloroacetic acid, ethanol and ethanol–ether, the residue from the sedimentable fraction was washed with ether, dried and hydrolysed with 0·3 *N* potassium hydroxide at 37°. After 4 hr. and 24 hr., portions were cooled in ice, and protein, deoxyribonucleic acid and potassium perchlorate were precipitated by the addition of perchloric acid. The amount of carbon-14 rendered acid-soluble was not increased by prolonging the hydrolysis beyond 4 hr., but some activity remained unextracted. The acid-soluble products were taken up in 60 per cent (v/v) aqueous ethanol and applied to strips of Whatman 3 *MM* paper for ionophoresis in 0·05 *M* ammonium formate buffer, *p*H 3·6.

Table 1. Distribution of Carbon-14 in Fractions of *Mycoplasma mycoides* grown in the Presence of DL-glycerol-1-$^{14}$C

| | c.p.m. | Per cent of total |
|---|---|---|
| Unfractionated suspension | 142,000 | (100) |
| Supernatant from frozen and thawed cells | 13,000 | 9 |
| Residue sedimented at 26,000*g*: | | |
| Cold trichloroacetic acid soluble | 800 | 1 |
| Ethanol-soluble, water-soluble | 5,800 | 4 |
| Ethanol-soluble, ether-soluble | 66,000 | 46 |
| Acid-soluble fraction of potassium hydroxide digest | 48,000 | 34 |
| | 133,600 | 94 |

Five heavily labelled bands were revealed by radioautography. These were well separated from each other and from the ribonucleotides, which were only feebly radioactive. The properties of the five concomitant compounds are summarized in Table 2. Ionophoresis was carried out by the hanging-strip method. The mobilities are corrected for electroendosmotic flow, but not for convection or other errors. Compounds I, II and III and their hydrolysis products were identified by chromatography in admixture with authentic carrier substances in at least three different systems.

Glycerol (G) and monoglycerophosphate (GP) were commercial products. α,α′-diglycerophosphate (GPG) was synthesized from DL-*iso*propylideneglycerol by the method of Fischer and Pfähler[3]. The phosphate esters were chromatographed as the ammonium salts and located with ammonium molybdate reagent[4]. Glycerol was located with silver nitrate. Incubation of compound V with the phosphatase gave a spot which migrated like GPG in four different systems. This suggested a structure (GPGP) in which an additional phosphate group was esterified to one of the remaining hydroxyls of GPG. Column 3 of Table 2 shows the changes in the relative densities of the bands on the radioautographs when the time of incubation in potassium hydroxide was increased from 4 to 24 hr. It suggests that compounds I, III and V, and perhaps II also, are formed by alkaline hydrolysis of IV. If so, one possible structure for compound IV was that consisting of three molecules of glycerol joined by two phosphate groups in diester linkage. This structure (GPGPG) is known to occur in the acidic phospholipid cardiolipin[5]. Cardiolipin was therefore prepared from fresh beef hearts[6] and saponified. The ethanol-insoluble potassium salt of the resulting polyglycerophosphate was converted to the

Table 2. Products of Alkaline Hydrolysis of the Residue Fraction

| No. | $M_s$* | Change 4–24 hr.† | Phosphatase‡ | Acid hydrol.§ | Diagnosis |
|---|---|---|---|---|---|
| I | 0·00 | Increase | — | — | G |
| II | 1·14 | Slight or nil | No change | G + GP | GPG |
| III | 1·47 | Increase | G | No change | α + β – GP |
| IV | 1·88 | Decrease | G + GP | G + GP | GPGPG |
| V | 2·30 | Increase | GPG | GP (+ G) | GPGP ? |

* Anionic mobility at *p*H 3·6 relative to that of uridylic acid.
† See text.
‡ Products of hydrolysis with crude acid phosphatase at *p*H 5·5.
§ Products of 10 min. hydrolysis in *N* hydrochloric acid at 100°.

ammonium salt and co-chromatographed with compound V in the following systems: water-saturated phenol ($NH_3$, HCN atmosphere), *iso*propanol/concentrated ammonia/water (70 : 6 : 30, v/v), and by ionophoresis at *p*H 3·5. In no case could separation of the radioactive material from the carrier be detected. No authentic sample of the dimer of glycerophosphate (GPGP) was available for comparison with compound V. It is of interest that several dinucleotides of analogous structure have been found among the products of alkaline hydrolysis of ribonucleic acid[7].

Consideration of the properties of the acidic phospholipids indicated that the procedure used might fail to extract them efficiently. It was found that, when the labelled cells were treated with 19 volumes of acetone at 0°, and then extracted with chloroform–methanol (2 : 1, v/v) at room temperature, no glycerophosphate compounds were present in alkaline hydrolysates of the residue. When the chloroform–methanol extracts were saponified, a large fraction of the carbon-14 was found in a substance which could not be separated from that obtained from cardiolipin when the two were co-chromatographed in the above three systems and also in *n*-butanol/acetic acid/water (5 : 2 : 3, v/v). Further work will be necessary to determine the nature of the substance extracted by chloroform–methanol, and its relationship to the process of 'glycerol-less death' (see preceding communication).

It is perhaps of more general interest that the ribonucleotide fraction, obtained from labelled cells which had been treated with cold trichloracetic acid before extraction with chloroform–methanol, still contained radioactive substances migrating faster than uridylic acid at *p*H 3·5. These were not found if the cells had been precipitated with 4 volumes of ethanol at 77°, or with cold acetone as described above.

P. Plackett

Division of Animal Health,
Animal Health Research Laboratory,
Commonwealth Scientific and
Industrial Research Organization,
Parkville, N.2,
Victoria, Australia.

[1] Rodwell, A. W., *Ann. N.Y. Acad. Sci.*, **79**, 499 (1960).
[2] Roberts, R. B., Abelson, P. H., Cowie, D. B., Bolton, E. T., and Britten, R. J., "Studies of Biosynthesis in *Escherichia coli*", Carnegie Inst. Wash. Pub. No. 607 (1955).
[3] Fischer, E., and Pfähler, E., *Ber.*, **53**, 1606 (1920).
[4] Burrows, S., Grylls, F. S. M., and Harrison, J. S., *Nature*, **170**, 800 (1952).
[5] Macfarlane, M. G., *Nature*, **182**, 946 (1958).
[6] Pangborn, M. C., Almeida, J. O., Maltaner, F., Silverstein, A. M., and Thompson, W. R., W.H.O. Monographs, No. 6, "Cardiolipin Antigens", second ed. (1955). Faure, M., and Morelec-Coulon, M. J., *Ann. Inst. Pasteur*, **91**, 537 (1956).
[7] Lane, B. G., and Butler, G. C., *Biochim. Biophys. Acta*, **33**, 281 (1959).

# BOTANICAL SURVEY OF INDIA

## PUBLICATIONS

1. **BULLETIN OF THE BOTANICAL SURVEY OF INDIA**
**B.O.B.S.I.** (a) Inauguration number 1959. Price: Rs.14.50 or £1 9s. or $4.50 nett.

(b) Annual subscriptions of subsequent volumes. Rs.32 or £3 4s. or $9.75.

2. **INDIAN LOCAL FLORA (REPRINTED EDN.)**

(a) Flora of the Presidency of Madras by Gamble and Fischer. Dy.8Vo. Rexine bound in 3 vols. Price: Rs.14.75 or £1 9s. 6d. or $4.50 nett.

(b) Flora of the Presidency of Bombay, by Cooke. Dy.8Vo. Rexine bound in 3 vols. Price: Rs.17.80 or £1 15s. 9d. or $5.50 nett.

**Please pay in advance and write to**

**THE CHIEF BOTANIST**
BOTANICAL SURVEY OF INDIA
14 Madan Street, Calcutta-13, India



## J. & A. CHURCHILL'S

*New and Important Volumes*

**AN INTRODUCTION TO FUNCTIONAL HISTOLOGY**
By GEOFFREY BOURNE, D.Sc., D.Phil.
*New (Second) Edition.* 181 illustrations. **32s.**

**Proceedings of the PNEUMOCONIOSIS CONFERENCE, 1959**
Edited by A. J. ORENSTEIN, *C.B., C.M.G., C.B.E.*, M.D., D.Sc., LL.D., F.R.C.P. 150 illustrations. **120s.**

**ELEMENTARY PHYSICS**
**For Medical, First Year University Science Students**
*New (10th) Edition.* By G. STEAD, M.A., D.Sc., F.Inst.P., and C. B. ALLSOPP, M.A., Ph.D., D.Sc., F.Inst.P. 465 illustrations. *Ready Feb.*

**pH AND BLOOD GAS MEASUREMENT**
**Methods and Interpretation**
A Symposium edited by R. F. WOOLMER, *V.R.D.*, B.A., B.M., B.Ch., F.F.A.R.C.S. 48 illustrations. **30s.**

**A TEXTBOOK OF PHARMACOGNOSY**
By T. E. WALLIS, D.Sc., F.R.I.C., Ph.C.
*Fourth Edition.* 245 illustrations. **50s.**

**New "Recent Advances"**

**RECENT ADVANCES IN HUMAN GENETICS**
Edited by LIONEL PENROSE, M.A., M.D., F.R.S. With the assistance of HELEN LANG BROWN. 13 illustrations. **27s. 6d.**

**RECENT ADVANCES IN PATHOLOGY**
*New (Seventh) Edition*
Edited by C. V. HARRISON, M.D.
140 illustrations. **48s.**

**RECENT ADVANCES IN BIOCHEMISTRY**
*New (Fourth) Edition*
By T. W. GOODWIN, D.Sc., F.R.I.C.
89 illustrations. **50s.**

**RECENT ADVANCES IN HUMAN NUTRITION**
**With Special Reference to Clinical Medicine**
By J. F. BROCK, D.M., F.R.C.P., and specialist contributors.
35 illustrations. *Just ready.* **50s.**

**Recent Ciba Foundation Volumes**

*General Symposia*

**ADRENERGIC MECHANISMS**
163 illustrations. **70s.**

**HAEMOPOIESIS: Cell Production and Its Regulation**
107 illustrations. **60s.**

**CONGENITAL MALFORMATIONS**
91 illustrations. **45s.**

*Study Groups*

**REGULATION OF THE INORGANIC ION CONTENT OF THE CELL**
15 illustrations. **12s. 6d.**

**VIRUS VIRULENCE AND PATHOGENICITY**
13 illustrations. **12s. 6d.**

**STERIC COURSE OF MICROBIOLOGICAL REACTIONS**
27 illustrations. **12s. 6d.**

104 GLOUCESTER PLACE, LONDON, W.1



A NEW INFOSEARCH TRANSLATION

## *Physics of Semiconductors*

A. F. IOFFE

Most of the late Prof. A. F. IOFFE's book is devoted to the physical phenomena of semiconductors, the rest to quantum theory, measurements and properties. Prof. Ioffe provided new data for this English edition.
500 pp. 155 illus. **84s.**

## *Problems in Quantum Mechanics*

I. I. GOLDMAN'S two widely used Russian collections, ably translated, now in one book: some 250 problems in non-relativistic quantum mechanics, fully worked, which could be used independently of a textbook. Edited by Dr. D. ter HAAR, Oxford.
400 pp. **42s.**

## *Magnetrons*

K. HINKEL provides an account of the applications of microwaves in general and magnetrons in particular; especially their physical background and properties. Short, clear and well illustrated with photos and circuit diagrams.
102 pp. 62 illus. **22s. 6d.**

## *Thyratrons*

C. M. SWENNE writes on the constitution, operation and characteristics of these widely used fast switching devices. An appendix gives technical data of current types.
106 pp. 68 illus. **15s.**

## *Using Transistors*

D. J. W. SJOBBEMA's introductory account of their theory also describes circuits that have proved effective, with transistors as amplifying elements.
120 pp. 120 illus. **15s.**

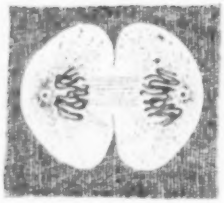
## *Electrical Theory on the Giorgi System*

P. CORNELIUS of Philips Research Laboratories studies fundamental electrical and mechanical theory as unified by this system. Teachers and their senior students will appreciate the interesting range of examples from engineering and physics: the conversion tables make it a useful reference.
187 pp. 28 illus. 32s.

CLEAVER-HUME PRESS, LTD.
London: 31 Wright's Lane, Kensington, W.8

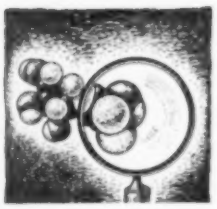
# *IT HAPPENED THIS MONTH...*

*a glance at yesterday in relation to today*



IN JANUARY—(1950)—a report[1] from the Karolinska Instutet in Stockholm discusses the effect of cold storage on mouse ascites tumor. There was a considerable loss of RNA but not DNA after 9 days at 4° C. Depletion of RNA is correlated with loss of virulence. Maintenance of a high nuclear DNA content indicates the cells survive the storage period and may possibly be interpreted as evidence of polyploidy.

*As cancer researchers become more and more interested in nucleic acid chemistry, they make increasing use of the full line of nucleic acid compounds available from Schwarz BioResearch. We supply DNA, RNA, nucleotides, nucleosides (including iodo- and bromo-deoxyuridine), purines and pyrimidines, sugars and sugar phosphates, plain and radiolabeled. Have you written for our latest catalog and price list?*



IN JANUARY—(1907)—*Chemical Abstracts* appears for the first time and summarizes[2] a paper by Emil Fischer on synthesis of polypeptides. This paper is of special interest because it describes the synthesis of the most complicated polypeptide ever prepared, consisting of a leucine and 11 aminoacetic acid residues. Fischer's new polypeptides closely resemble natural peptones in their water solubility and in failure to crystallize.

*The techniques and basic knowledge discovered by Fischer have enabled modern organic chemists to synthesize peptides of far greater complexity. The Yeda Research and Development Company produces a wide variety of peptides, polyamino acids, and carbobenzoxy amino acid compounds, which are distributed by Schwarz BioResearch. Inquiries are invited for quotations on your special requirement. Yeda is equipped to make to your order a host of specialized compounds.*

IN JANUARY—(1800)—J. J. Virey, of the Val de Grace, reports on the effects of animal aliments upon the human body. He states, "It is erroneous to maintain, that the nutritive quality is principally in the gelatinous substance of animals, since this is much less nourishing than the albuminous substance. The latter, when entirely animalized, requires only a light exercise, and a greater degree of oxygenation, to be converted into fibrous substance; but the gelatinous matter, being analagous to the mucilaginous substance of vegetables, requires a greater effort of nature for assimilation, and a more considerable separation of carbon and hydrogen."[3]

*If you are doing nutritional research involving essential or nonessential amino acids, from albuminous or gelatinous sources, Schwarz BioResearch can supply you with bulk quantities at low cost. We produce a long list of amino acids and derivatives labeled with $C^{14}$, $N^{15}$, and $S^{35}$. In addition, we are the distributor of $O^{18}$-labeled amino acid compounds produced to order by Yeda Research and Development Company, Ltd. at the Weizmann Institute of Science in Israel.*

1. Klein, E.; Kurnick, N. B., and Klein, G.: The effect of storage on the nucleic acid content and virulence of mouse ascites tumor. Exper. Cell Research *1*:127 (Jan.) 1950. 2. Fischer, E.: Synthesis of polypeptides. XV. Chem. Abstracts *1*:51 (Jan.) 1907. 3. Virey, J. J.: General remarks on aliments produced by the different classes of the animal kingdom, and their influence on the human body. Med. & Phys. J. *3*:65 (Jan.) 1800.

SCHWARZ BIORESEARCH, INC. • Dept. IH • Mount Vernon, New York

BIOCHEMICALS • RADIOCHEMICALS • PHARMACEUTICALS *for research, for medicine, for industry*

THE FARADAY SOCIETY

AN INFORMAL DISCUSSION ON

**Mechanisms of the Gas-Phase Reactions of the Halogens and their Compounds**

will be held in the Chemistry Department, University College, Cardiff, on Tuesday, March 28, 1961.

The programme will be divided into two sections :

A. Oxidation processes.
B. Reactions of elementary halogens.

For further information, please apply to Dr. J. H. Thomas, Chemistry Department, University College, Cathays Park, Cardiff.

**COLOUR SLIDES**

*Nymphaea alba, White Waterlily*
*From British Wild Flowers (Second Series)*

Other subjects include Cabbage White, Poplar Hawk, Dodder and Pine Life Histories, and Marine Biology. Obtainable either as sets with notes or as individual slides

*Catalogues on application*

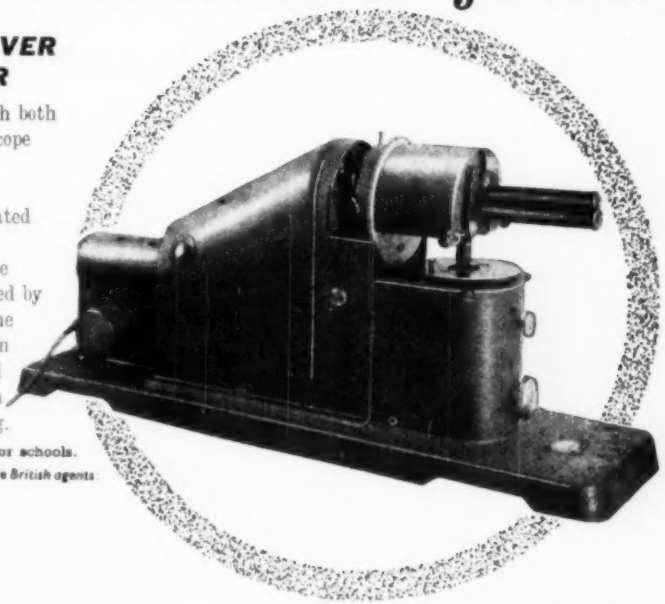
**FLATTERS & GARNETT LTD**
309 Oxford Road Manchester 13

**ZEISS Revolver Micro-Projector...**

***THE ZEISS REVOLVER MICRO-PROJECTOR***

permits micro-projection with both compound and simple microscope combinations and also the projection of 2" x 2" slides. Six objectives suitably graduated for different magnifications are simply switched into place and automatically accompanied by the appropriate condenser. The arc lamp has automatic carbon feed and a water chamber and special filter provide specimen protection against overheating.

**A smaller model is also available for schools.**
*Illustrated booklet on request from the sole British agents*



Degenhardt
AND COMPANY LIMITED

6 CAVENDISH SQUARE · LONDON · W1 · TELEPHONE: LAN 6097

*Sofnol non-hygroscopic Soda-lime is used in leading London Hospitals and throughout the world for anaesthetic and metabolic apparatus.*

**SOFNOL**

**NON-HYGROSCOPIC SODA-LIME**

SOFNOL LTD., WESTCOMBE HILL, GREENWICH, LONDON, S.E.10

TAS/SL 324

**WANTED TO PURCHASE**

*Scientific books & periodicals*

*Entire libraries, and smaller collections; sets and runs, foreign and domestic.*

**WALTER J. JOHNSON, INC.**
111 Fifth Avenue, New York, 3, N.Y., U.S.A.
*Cable Address:* BOOKJOHNS, NEWYORK
British Office: ACADEMIC BOOKS, LTD.
17 Old Queen St., London, S.W.1
WHItehall 6631

BACK ISSUES OF JOURNALS IN SCIENCE & THE HUMANITIES
ALWAYS REQUIRED BY
WM. DAWSON & SONS, LTD.,
BACK ISSUES DEPT.,
16 WEST STREET,
FARNHAM, SURREY, ENGLAND.
TEL: FARNHAM 4664 CABLES: DAWBOOKS, FARNHAM

**"E.R.L." RUBBER HOLDERS**
**FOR TEST TUBES, AMPOULES, etc.**
*Made in 8 sizes, either in black, synthetic or softer red organic rubber: price 20/- each*
**ESCO (RUBBER) LTD.**
*34 36 Somerford Grove, London, N.16*

**HOSLAB**
Regd. Trade Mark
Laboratory Equipment

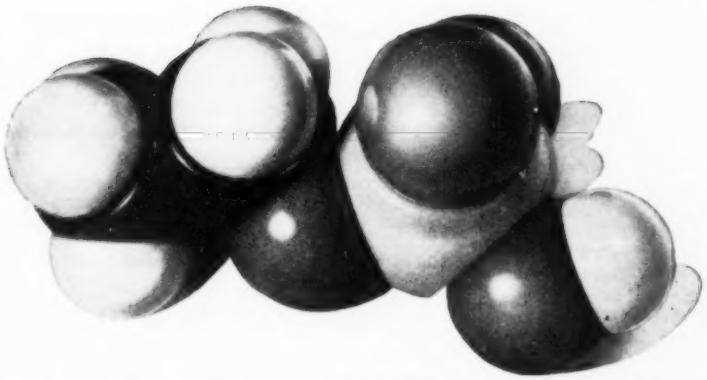
*Stockists of*

VOSS MAGNETIC STIRRERS and HOT PLATES

For details, write or visit
**HOSPITAL AND LABORATORY SUPPLIES LTD.**
12 CHARTERHOUSE SQUARE
LONDON, E.C.1
*Telephones: Clerkenwell 4840, 7941*

COMPLETE LABORATORY FURNISHERS

Put them together-and what have you got?



**ETHYL**

**HYDROGEN**

**SULPHATE**

# CATALIN MOLECULAR MODELS

Catalin Molecular Models demonstrate the complexities of molecular structure, and are used extensively in universities and other teaching establishments, both in Great Britain and overseas. They are accurately dimensioned after the Stuart pattern and consist of spheres distinctively coloured in accordance with the Institute of Physics. Catalin Molecular Models comprise eleven elements in their various valency states: HYDROGEN · PHOSPHOROUS · NITROGEN CARBON · OXYGEN · SILICON · SULPHUR FLUORINE · CHLORINE · BROMINE IODINE. Each element is designed to give appropriate representation to the three basic dimensions of the atom:

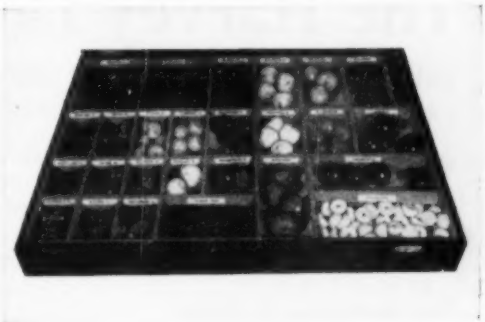
**SPHERICAL DIAMETER · BOND LENGTH · BOND ANGLE**

*Precision machined from highly durable Catalin cast phenolic resin, Catalin models are available in two sets:*

**STANDARD SET . . . 250 UNITS**
**STUDENTS' SET . . . 110 UNITS**

*Complete with accessories in partitioned and lined leathercloth folding case.*

**Separate units of all elements are also supplied.**
*Models for double or treble bonds are fitted with locking pins.*



**Catalin Limited**

MM5

*Please write for full information to:* **CATALIN LIMITED, WALTHAM ABBEY, ESSEX · TELEPHONE: WALTHAM CROSS 23344**

**ACADEMIC PRESS** New York and London

*The first succinct presentation in English*

# The Glycolysis and Respiration of Tumors

*By* ALAN C. AISENBERG
*Harvard Medical School*
*January* 1961, 224 *pp., illus.*, 64*s.*

**PART I: The Anaerobic and Aerobic Glycolysis of Normal and Tumor Tissues**
- Anaerobic and Aerobic Glycolysis in the Surviving Tissue Slice and in Ascites Cells
- Tumor Glycolysis *in Vivo*
- Tumor Glycolysis in Extracts and Homogenates
- Metabolic Inhibitors of Glycolysis
- Glycolytic Enzymes in the Blood

**PART II: The Oxidative Metabolism of Tumors**
- The Over-All Respiratory Rate of the Tumor Slice
- Nature of the Substrate of Tumor Respiration
- Carbohydrate Oxidation in Tumor Tissue
- The Metabolism of Fatty Acids by Tumor Tissue
- The Hexose Monophosphate Shunt in Tumors
- The Requirement for DPN and Other Nucleotide Additions in the Oxidative Metabolism of Tumors
- Oxidative Phosphorylation in Tumor Mitochondria
- Number and Nitrogen Content of Tumor Mitochondria
- Miscellaneous Studies on Tumor Mitochondria
- The Levels of Specific Oxidative Components in Tumors
- Warburg's Theory of a Damaged Tumor Respiration

**PART III: Regulatory Mechanisms in Respiration and Glycolysis**
- The Pasteur Effect
- The Crabtree Effect

**PART IV: The Dependence of Tumors on Oxidative and Glycolytic Energy**
- The Dependence of Synthetic Processes on Oxidative and Glycolytic Energy
- The Nature of the Energy Supply for Cell Division
- The Relationship of Tumor Survival to Glycolysis and Respiration

**PART V: Summary and Conclusions**
- Summary
- Relationship of the Energy Metabolism of Tumors to the Fundamental Nature of the Neoplastic Process

APPENDIX: Chart 1. Glycolysis. Historical Review

REFERENCES

SUBJECT INDEX.

# The Harvey Lectures *Series 55*

**Delivered under the auspices of The Harvey Society of New York 1959-1960**

*Under the patronage of the New York Academy of Medicine*

*February* 1961, 257 *pp., illus., approx.* 60*s.*

**Quantitation of Growth of Mammalian Cells**
*By* T. T. PUCK

**The Biological Foundations of Wound Repair**
*By* PAUL WEISS

**Neurotransmission in the Adrenergic Nervous System**
*By* U. S. VON EULER

**Iron Metabolism and Nutrition**
*By* CARL V. MOORE

**Inside Nucleic Acids**
*By* PAUL DOTY

**Renal Mechanisms for Potassium Excretion**
*By* ROBERT W. BERLINER

**The Role of $N_2$ Gas in Various Biological Processes with Particular Reference to the Lung**
*By* HERMANN RAHN

**The Role of Fetal Hormones in Prenatal Development**
*By* ALFRED JOST

*Previously published*:
Series 47–49, 1953–1955, 60s. each
Series 50, 1956, 64s.
Series 51–54, 1957–1960, 60s. each

111 FIFTH AVENUE, NEW YORK 3 | 17 OLD QUEEN STREET, LONDON, S.W. 1

111 FIFTH AVENUE, NEW YORK 3 17 OLD QUEEN STREET, LONDON, S.W. 1

*Phone*: WHitehall 6631

# The Structure of the Eye

Proceedings of the Symposium held April 11–13, 1960, during the Seventh International Congress of Anatomists, New York

*Edited by* G. K. SMELSER

*College of Physicians and Surgeons, Columbia University*
*January* 1961, 570 *pp., illus.*, 107*s.* 6*d.*

**This volume provides an up-to-date report on the status of modern concepts of eye structure. The contributions included reflect the increasing recognition among investigators in diverse fields of the unique value of the eye for fundamental research on such problems as metabolic interrelationships, immunochemistry, protoplasmic reaction to stimuli, as well as physical problems concerning the mechanisms of light detection.**

**The results reported are based on studies using modern methods of electron microscopy, histochemistry, radioautography, and the tools of immunology.**

*Detailed table of contents available upon request.*

*Now complete*

# The Structure and Function of Muscle

*Edited by* G. H. BOURNE

*Emory University, Atlanta, Georgia*

**Volume 1 Structure**
1960, 472 *pp., illus.*, 100*s.*

**Volume 2 Biochemistry and Physiology**
1960, 593 *pp., illus.*, 118*s.*

**Volume 3 Pharmacology and Disease**
1960, 489 *pp., illus.*, 107*s.* 6*d.*

This treatise provides an encyclopedic reference work concerning all aspects of muscle. Primary emphasis has been placed upon skeletal muscle, but a considerable portion of the text is devoted to smooth and to cardiac muscle.

The various chapters have been written by scientists who bring to this work the authority of their wide knowledge and experience. Their cooperation has brought together material heretofore available only in widely scattered sources. In combination, the lists of references following each chapter form a comprehensive bibliography on muscle.

*Complete contents of all volumes listed in September* 24, 1960, *issue of* Nature, *or available upon request.*

**ACADEMIC PRESS New York and London**

**BRITISH HIGH PRESSURE AUTOCLAVES**

Tilting, Shaking, Rotating and Vertical types.
Autoclaves to special design.
Pressures up to 500 atms.
Temperatures up to 500 degs. Cent.
Capacities 50 ml. to 5 litres.
Stainless steel throughout to EN58 specs.
Electrically heated.

*

**Controlling, recording or indicating instruments supplied to customer's preference.**

*

*Send details of your requirements to the actual manufacturers.*

**CHAS. W. COOK & SONS, LTD.**
**97 Walsall Rd., Perry Barr, Birmingham, 22B, England**

If you are interested in
**BLOOD BANKS**
ask for particulars of
**THE BRENTWOOD**
ROBERT C. SCUTT LTD.
*Designers and sole manufacturers of "Brentwood" Blood Banks.*
47 STATION ROAD, WINCHMORE HILL
LONDON, N.21. LABurnum 6262
*Every enquiry is given personal attention by one of our Directors.*
Export Enquiries to: Dodwell & Co. Ltd., 18 Finsbury Circus, London, E.C.2.

**"GURR'S"** *is the Registered Trade Mark of* **GEORGE T. GURR, LTD.**
Since 1915 **"GURR'S"** brand of **MICROSCOPICAL STAINS** and Reagents has become world-famous.
If you want this world-famous brand, specify **"GURR'S"** and refuse any other.
*Ask for catalogues*
**GEORGE T. GURR LTD.**
**136-138 NEW KINGS ROAD, LONDON, S.W.6**

**SPICER'S ZIRCONITE**
MACHINABLE REFRACTORY
• SOLVES A LOT OF PROBLEMS
• SAVES A LOT OF TIME
*Machinable Alumina now available*
**W. & C. Spicer Ltd., The Grange, Kingham, Oxon.**
TELEPHONE: KINGHAM 307

**RESIN IMPREGNATION**

*of wire-wound components under vacuum*

N.G.N. new 'Resin-impregnating Plant' not only ensures better and far more thorough impregnation of all types of wire coils—its faster cycle of operation, coupled with carefully designed thermostatic control of vessels and pipework, plus full bore resin transfer valve, all combine to speed output while reducing costs.

Work chamber is evacuated to 1 micron Hg. to degas and dehydrate components which are then impregnated under a pressure of 80 lbs. p.s.i.

Surplus impregnant is completely recovered. Absolute reliability, both as regards thoroughness of impregnation and regular output is assured.

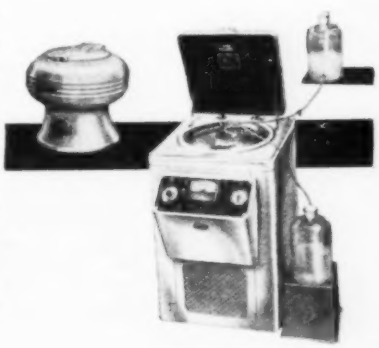
Enquiries for special plant to user requirements are especially welcome.

**N.G.N. ELECTRICAL LIMITED**
AVENUE PARADE, ACCRINGTON, LANCS. Tel: Accrington 35611-2

# THE ONE CENTRIFUGE YOU WANT IS IN THE MSE RANGE — TWENTY ONE DIFFERENT MODELS

The MSE range of centrifuges is wide because the scope of centrifuging practices and techniques is wide. The individual centrifuge user can be confident of finding, in the MSE range, the centrifuge which most effectively and economically fulfils his purpose.

No less important than the wide range of choice is the reliability of MSE Centrifuges and the service which backs them. Trained Service Engineers are always available at short notice, and individual contracts for regular servicing and maintenance are in operation in very many laboratories.



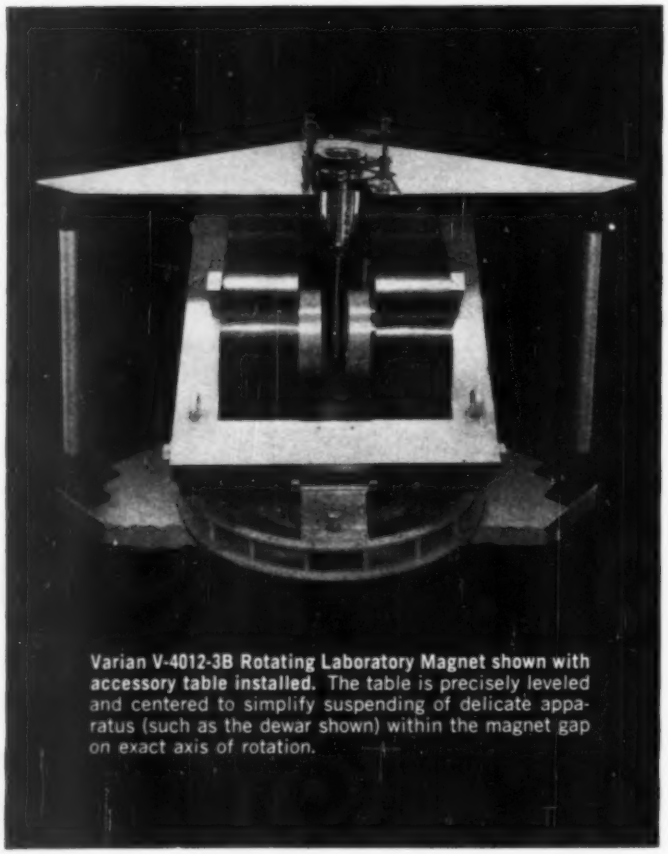
MSE

MEASURING & SCIENTIFIC EQUIPMENT LTD.
Spenser St., London, S.W.1. Telephone: VICtoria 5426.
GD539

FROM VARIAN

12-INCH PRECISION LABORATORY MAGNETS

# LARGE HOMOGENEOUS MAGNETIC FIELDS



**Varian V-4012-3B Rotating Laboratory Magnet shown with accessory table installed.** The table is precisely leveled and centered to simplify suspending of delicate apparatus (such as the dewar shown) within the magnet gap on exact axis of rotation.

**Field homogeneity in a useful third dimension**

Presented here for the first time, a three-dimensional plot from a 12-inch Varian Magnet reveals over 100 cc of highly homogeneous field available to the experimental physicist. This volume is a technical accomplishment because field homogeneity normally falls off rapidly with increasing gap width. It demonstrates again how Varian's long experience puts extra value into these magnet systems.

**Easy accommodation of bulky experimental apparatus**

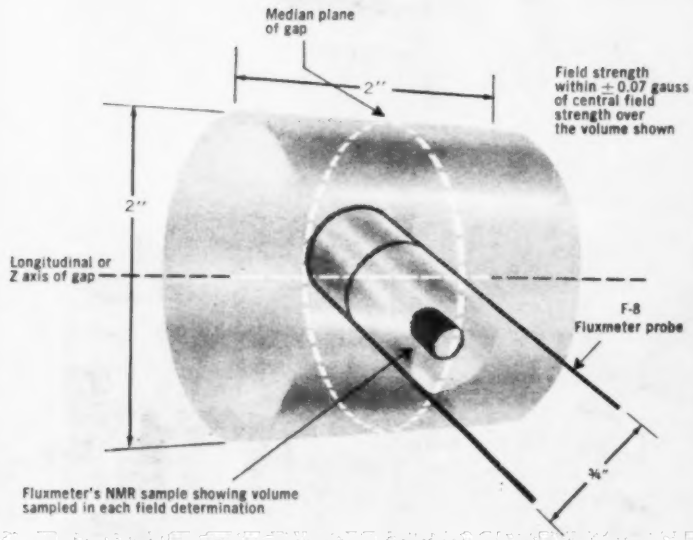
The large field shown is highly useful in two respects. The over-all air gap width of nearly three inches is sufficient to hold glass dewars and other apparatus surrounding the field-sensitive sample or object. And your sample itself may be of any bulk and dimensions up to those shown and still fall inside a field homogeneous within ± 0.07 gauss of the 3550 gauss central field strength. Outstanding performance is also attainable at other field strengths.

**A versatile range of other capabilities**

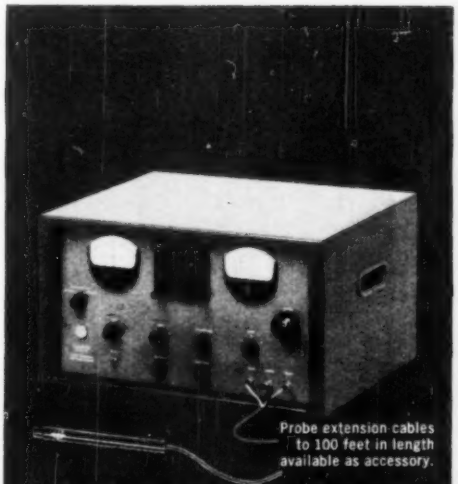
Much higher magnetic field strengths are available by purchase of additional pole cap configurations for smaller air gaps. The extra cost is nominal. And the magnet provides a useful volume of homogeneous field at these higher strengths. Thus as a long-range investment a Varian Magnet is adaptable to needs unforeseen at time of purchase.

Write today for the new 32-page magnet brochure which gives specifications on Varian's full magnet line. Address Instrument Division.

# IN WIDE AIR GAPS


Median plane of gap
2″
Field strength within ± 0.07 gauss of central field strength over the volume shown
2″
Longitudinal or Z axis of gap
F-8 Fluxmeter probe
¾″
Fluxmeter's NMR sample showing volume sampled in each field determination

**More than 100 cc of homogeneous magnetic field within 3-inch central air gap.** Three-dimensional cylindrical field of Varian 12-inch magnet shown full scale in oblique view; ring shim pole caps used; field strength 3550 gauss.



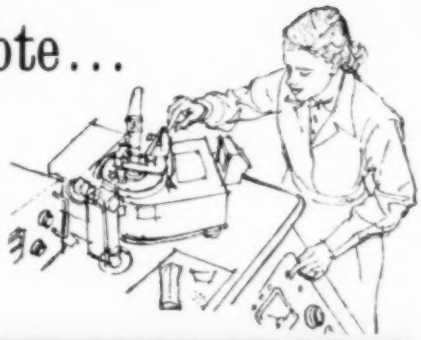

**VARIAN F-8 FLUXMETER with new crystal frequency control.** Time stability and accuracy enable the Varian Fluxmeter to make homogeneity field plots. The fluxmeter probe (at left) is shown extended into the magnet gap as actually done in making the field plot.

The F-8 can provide direct stabilization of magnetic fields by utilization of the D.C. error signal output. The F-8 is perfectly matched to the Varian 6- and 12-inch magnet system power supplies, and readily adapts to others.

**VARIAN associates**
PALO ALTO 26, CALIFORNIA

NMR & EPR SPECTROMETERS, MAGNETS, FLUXMETERS, GRAPHIC RECORDERS, MAGNETOMETERS, MICROWAVE TUBES, MICROWAVE SYSTEM COMPONENTS, HIGH VACUUM EQUIPMENT, LINEAR ACCELERATORS, RESEARCH AND DEVELOPMENT SERVICES

# Make an instrumental note...



that if you have anything to analyse, to measure, inspect, or survey, the people to help you are Hilger & Watts.

Spectrometers, Autocollimators, Spectrophotometers, Block Levels, Polarimeters, Clinometers, Refractometers, Dividing Engines, Electrophoresis Apparatus, Microscopes, Theodolites, Interferometers, Levels, Digitizers, Photogrammetric Instruments, Etc.

HILGER & WATTS LTD • 98 ST PANCRAS WAY • LONDON • NW1

HILGER & WATTS LTD., DORTMUND HORDE, GERMANY

HILGER & WATTS INC., CHICAGO 5, U.S.A.

# LETTERS TO THE EDITORS

## ASTROPHYSICS

### The Dust Cloud about the Earth

THE existence of a high concentration of interplanetary dust near the Earth has recently been demonstrated from rocket, satellite and space-probe observations of acoustical impact. Suspected by Beard[1], the concentration has been proved by me[2] and by Hibbs[3]. To a distance of approximately $10^5$ km., the concentration falls off roughly as the inverse 1·4 power of the distance from the Earth's surface (Fig. 1). The impact-rates on randomly oriented surfaces include all particles greater than mass $10^{-9}$ gm. and are adjusted for the differing sensitivities of the equipment. Data are from six U.S. rocket firings; from satellites *Explorer I* (1958 Alpha), *Sputnik III* (1958 Delta) and *Vanguard III* (1959 Eta); and from the space probes *Explorer VI* (1959 Delta) and *Pioneer I*. At some distance greater than $10^5$ km., the impact-rates approximate those expected from calculations on the zodiacal cloud; the maximum concentration with respect to the interplanetary medium is perhaps as high as $10^3$.

Four possible explanations for the dust concentration cannot immediately be eliminated by simple physical arguments: (1) The electrostatic explosion of fragile particles by charges ($\sim 100$ V.) induced in the radiation belts of the Earth. (2) Capture into temporary circumterrestrial orbits by high-charge, high-drag processes in the radiation belts of the Earth. (3) Gravitational capture into temporary circumterrestrial orbits in the four-body system of Earth–Moon–Sun and particle (Beard's prediction). (4) Expulsion of dust and droplets from the Moon by meteoritic crater formation into temporary cislunar orbits.

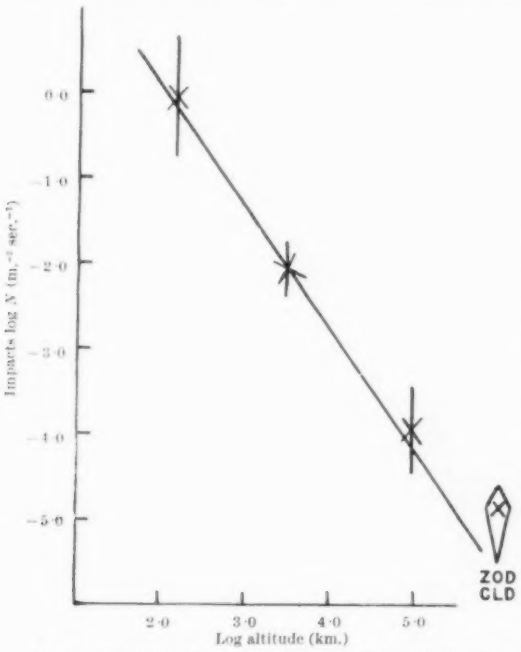



Fig. 1. Meteoritic impact (mass = $10^{-8}$ gm.) versus altitude from the Earth

Since there is no clear evidence that the Earth's radiation belts produce high electrostatic charges on particles, explanations (1) and (2) must be viewed sceptically until demonstrated. Gravitational capture of interplanetary particles by the Earth–Moon system appears to be a process of extremely small probability ($< 10^{-5}$ ?), but may be significant if the interplanetary orbits are nearly circular and of low inclination to the ecliptic. This type of motion has not been demonstrated. If capture orbits can persist for an unlikely $10^8$ revolutions about the Earth, the small expected capture-rate might be adequate. I cannot verify Beard's theory of the three-body (Sun–Earth–particle) capture process, while Beard's predicted law of particle concentration near the Earth does not agree with the observed law. Hence explanation (3) shows doubtful promise.

Let us consider explanation (4). Meteoritic bodies of cometary and asteroidal origin certainly strike the Moon at high velocities, up to 73 km./sec., with perhaps a median value near 15–20 km./sec. Direct encounters from interplanetary orbits occur for the Moon at a rate less than 1/16 that for the Earth, this areal ratio being further reduced by the greater gravitational attraction of the Earth. The over-all rate may be approximately 2–3 per cent that for the Earth. No adequate theory yet predicts the high-velocity ejection component in crater-forming impacts. The solid material must consist almost entirely of dust and droplets, whatever the nature of the lunar surface; large ejection bodies, as suggested by Urey[4], should be extremely rare. Perhaps the dust ejected into cislunar orbits ($2{\cdot}4 <$ velocity $< 3{\cdot}4$ km./sec.) may be a few per cent of the total mass striking the Moon, or of the order of $10^{-3}$ times the total meteoritic material directly striking the Earth. Since fine dust appears to be only a few per cent of the total solids striking the Earth directly, the two rates may be comparable within one or two orders of magnitude. From drag considerations, temporary circumterrestrial orbits for $10^{-9}$ gm. particles may possibly persist for $10^5$–$10^6$ revolutions. If, indeed, the dust concentration factor is then greater than $10^3$ within the Moon's orbit, the dust cloud about the Earth is semi-quantitatively explained. The higher concentration near the Earth would arise from convergence of the orbits and drag effects.

Thus a lunar origin for the dust seems fairly tenable. The hypothesis will predict a concentration in the plane of the Moon's orbit with generally a direct (eastwardly) motion of the particles. The dust cloud

would be more comparable to the zodiacal cloud about the Sun than to the rings of Saturn (suggested by Hibbs). If this explanation is valid, the direct motion and distribution should be readily measurable in space experiments and the diurnal effects should be small for orbits close to the plane of the Moon's orbit.

Much more observational, analytical and theoretical research is required to clarify this surprising phenomenon.

Fred L. Whipple

Harvard College Observatory,
and
Smithsonian Astrophysical Observatory,
Cambridge 38, Massachusetts.

[1] Beard, D. B., *Astrophys. J.*, **129**, 496 (1959).
[2] Whipple, F. L., "Particulate Contents of Space" in "Medical and Biological Aspects of the Energies of Space", edit. by Campbell, P. (in the press).
[3] Hibbs, A., private communication; *J. Geophys. Res.* (in the press).
[4] Urey, H. C., "Primary and Secondary Objects", in "The Exploration of Space", edit. by Jastrow, R., 77 (Macmillan Co., New York, 1960).

## Ionospheric Disturbance at the Time of Cosmic Ray Increases

In a recent communication Legrand and Helary[1] have reported the occurrence of an anomalous increase in the intensity of the total cosmic ray component at the Paris Cosmic Ray Survey Station on December 4, 1957. At about the same time an increase was also observed in the intensity of the nucleonic component at Thule, Greenland. This cosmic ray event was further described as being analogous to one which was observed at Paris on January 21, 1957 (ref. 2). It has been suggested that these events are manifestations of the precipitation into the Earth's atmosphere of high-energy protons which emanate from the disturbed Sun.

Such cosmic ray increases at ground-level are rare, and their relationship to terrestrial atmospheric disturbances is not yet well understood. It is of interest, therefore, to consider conditions obtaining in the Earth's atmosphere at the time of such cosmic ray enhancements.

The ionospheric measurements reported here have been taken from the data collected by high-frequency vertical-incidence sweep-frequency sounders at Resolute Bay, Baker Lake and Ottawa. These stations have geomagnetic latitudes of 82·9°, 73·7° and 56·9° respectively. The ionosondes are part of a net which has been operated in and near the auroral zone for a number of years by the Department of Transport for the Defence Research Telecommunications Establishment of the Defence Research Board, Ottawa. The sweep-frequency equipment is conventional (2–20 Mc./s.) and soundings are taken continually at 15-min. intervals. The solar and magnetic data were taken from the monthly bulletin, *Solar Geophysical Data*, Part *B*, published by the National Bureau of Standards, Boulder, Colorado.

The cosmic ray increase on December 4, 1957, occurred during a period of low solar activity. An examination of the data from the Canadian ionosondes showed that there were no unusual conditions in the early part of December. All the ionospheric measurements remained very close to the monthly median values for several days before and after the cosmic ray enhancement.

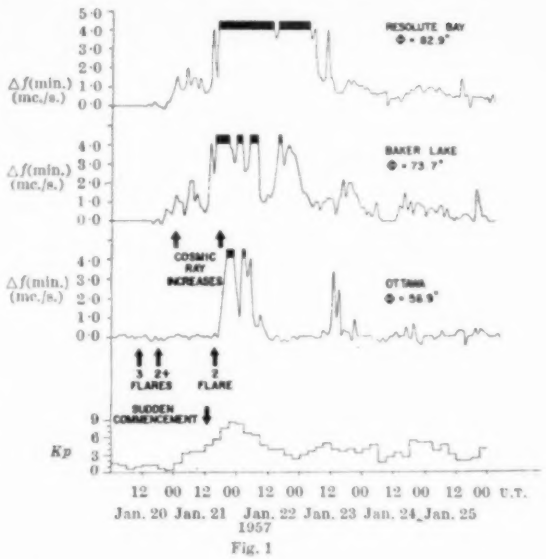



Fig. 1

The increase which was observed on January 21, 1957, occurred at a time of somewhat higher solar activity and the ionospheric conditions were quite different and considerably more complex. Both a geomagnetic storm and a polar-cap absorption event were observed during this period.

The polar-cap absorption event is now a familiar phenomenon, and, as a result of the International Geophysical Year work on radio-wave absorption at high latitudes, the gross features of these disturbances are fairly well known[3,4]. During a polar-cap absorption event the enhanced ionization in the lower ionosphere extends over the whole polar cap as far south as geomagnetic latitudes of approximately 60°. The disturbance lasts for several days and is much more intense when the ionosphere is sunlit. At such times high-frequency radio waves are completely absorbed, and very-high-frequency waves also suffer severe attenuation. It is generally believed that polar-cap absorption events are another manifestation of the precipitation of solar protons although these protons probably have somewhat lower energies (10–100 MeV.) than those responsible for the cosmic ray increase observed at the surface of the Earth[2].

Some of the measurements from three of the Canadian ionosondes which show the nature of the ionospheric disturbance in January 1957 are presented in Fig. 1. The three curves show the deviations from the monthly median values of the hourly values of $f$(min.) at Resolute Bay, Baker Lake and Ottawa. $f$(min.) is the lowest frequency reflected from the ionosphere. Since the lower frequencies are attenuated more strongly than the higher frequencies an increase in the value of $f$(min.) denotes an increase in absorption and hence an increase in the electron density in the lower ionosphere. The heavy horizontal bars at the tops of the curves represent intervals of blackout or complete absorption of the sounding transmission. The magnetic activity for the period (January 1957) is given by the histogram of $Kp$ at the bottom of Fig. 1. An arrow denotes the time of the magnetic storm sudden commencement. Arrows marking the occurrence of flares are for the large

solar eruptions which one might reasonably associate with the ionospheric effects. Times of maxima of cosmic ray increases have been taken from the report published by Legrand, Chanson and Bonpas[2].

It can be seen that the increase in $\Delta f$(min.) at the high-latitude stations on January 20 which marks the start of the polar-cap absorption began within a few hours of the first two large solar flares and was roughly coincident with the first cosmic ray increase. The second cosmic ray increase on January 21, which was slightly more intense than the first, followed the third flare by several hours. It has since been reported that the geomagnetic storm which began with the sudden commencement at 1230 on January 21 was accompanied by a Forbush decrease which began at Ottawa at 21 hr. (ref. 5).

Because of the timing, it seems likely that the magnetic storm and the Forbush decrease might be associated with the flares which occurred on January 20. One of these flares, it may be assumed, must have ejected particles with a wide range of energies if it were responsible for the observed ground-level increase of cosmic rays, the polar-cap absorption and the magnetic storm. Just what contribution was made to these events by particles from the third flare on January 21 is difficult to say since the polar-cap absorption event and the magnetic storm were already in progress at the time this flare occurred. It seems possible, however, that this last solar outburst produced only particles with very high energies since the polar-cap absorption event at Baker Lake was much reduced on January 22 and there was no second sudden commencement, nor was there any marked increase in the magnetic activity around January 23. Although the blackout at Ottawa occurred soon after the flare on January 21, it is not likely that these two events were related. It seems more probable that the particles producing the blackout at this station came from one of the flares on January 20 and were precipitated at the lower latitudes because of the distortion of the geomagnetic field at the time of the storm. This effect has been discussed by Freier, Ney and Winckler[6] in their description of the detection of solar cosmic rays below the normal cut-off rigidities appropriate to the latitude of Minneapolis on March 26, 1958.

The association of the foregoing events is of course highly speculative. It would seem, however, that although the cosmic ray increases in January and December of 1957 were in some respects analogous, they were associated with quite different ionospheric conditions. Further observations at the time of such cosmic ray increases are required to establish the nature of this relationship.

C. Collins
D. H. Jelly

Defence Research Telecommunications Establishment,
Defence Research Board,
Ottawa.

[1] Legrand, J. P., and Helary, A., *Nature*, **187**, 397 (1960).
[2] Legrand, J. P., Chanson, P., and Bonpas, M., *C.R. Acad. Sci., Paris*, **244**, 1362 (1957).
[3] Reid, G. C., and Leinbach, H., *J. Geophys. Res.*, **64**, 11, 1801 (1959).
[4] Collins, C., Jelly, D. H., and Matthews, A. G., *Canad. J. Phys.* (in the press).
[5] Fenton, A. G., McCracken, K. G., Rose, D. C., and Wilson, B. G., *Canad. J. Phys.*, **37**, 970 (1959).
[6] Freier, P. S., Ney, E. P., and Winckler, J. R., *J. Geophys. Res.*, **64**, 685 (1959).

## RADIOPHYSICS

### Irregular Fading of Satellite Transmissions

In a paper by Kent[1] it was stated that irregular fading of satellite transmissions on 40 Mc./s. from *Sputnik* 1 did not occur when the satellite was south of 50° N., and indeed was of very small amplitude on the average when the magnetic inclination at the sub-satellite point was less than 68°, the value at the observing station near Cambridge. Mawdsley[2] has suggested that this might be due not to the absence of irregularities to the south of Cambridge but to the southerly irregularities being incorrectly oriented to give appreciable power scattering to the receiver.

Some observations made at Slough on transmissions from the satellite *Explorer* 7 at a frequency of 20 Mc./s. are of relevance in this connexion. Although this satellite never reaches as far north as the latitude of Slough, irregular fluctuations are frequently found on the signal-strength records; they were of greater magnitude at night than during the hours of daylight. If a scintillation index is defined, as is commonly done, by the ratio of the standard deviation of the fluctuations to the mean signal amplitude, then the distribution of the mean index with magnetic inclination is as shown in Table 1; a separate index was calculated for each half-minute of record.

Table 1. Mean Scintillation Index in Certain Ranges of Magnetic Inclination of the Sub-satellite Point. Night-time Results Only, for the Period January–February 1960

| Ranges of magnetic inclination (deg.) | No. of indices in each range | Mean index |
|---|---|---|
| 50–56 | 23 | 0·10 |
| 56–58 | 23 | 0·11 |
| 58–60 | 30 | 0·14 |
| 60–62 | 59 | 0·14 |
| 62–64 | 93 | 0·18 |
| 64–66 | 206 | 0·17 |
| 66–68 | 121 | 0·24 |
| 68–70 | 13 | 0·27 |

The inclination at Slough is 67°; it can be seen that there are scintillations well to the south of Slough, although the index certainly tends to fall off as the satellite moves away from magnetic north. The decrease is not so sharp and does not continue to such a low level as that found by Kent on the 40 Mc./s. transmissions he observed.

The height of *Explorer* 7 lay in the range 550–800 km. during these observations. The positional information on which the work was based was derived from prediction data. Consequently the figures in Table 1 may be subject to errors of up to 2° in the magnetic inclination of the sub-satellite point; this is not sufficiently large to affect the conclusions given above.

This work forms part of the programme of the Radio Research Board. This communication is published by permission of the Director of Radio Research of the Department of Scientific and Industrial Research.

W. C. Bain

Radio Research Station,
Department of Scientific and Industrial Research,
Slough.

[1] Kent, G. S., *J. Atmos. Terr. Phys.*, **16**, 10 (1959).
[2] Mawdsley, J., *J. Atmos. Terr. Phys.*, **18**, 344 (1959).

## PHYSICS

### Random Fluctuations in a Nuclear Fission Reactor

THE theory of the stochastic dynamics of a nuclear fission reactor has been formulated by Moore[1]. The present investigation is concerned with the measurement of time-dependent reactor parameters, using a spectral analysis technique and the formulation of both theory and experiment for the correlation analysis and measurement of spatially dependent reactor parameters.

The time-trace of the random fluctuations in neutron density in a nuclear reactor operating autonomously at low power has been recorded. From the direct recording of this 'noise' wave-form an amplitude spectrum and a spectral density-curve have been derived. Conclusions have been drawn concerning: (1) the effective, prompt neutron lifetime in the reactor; (2) the reactor transfer function.

Further experiments will be aimed at: (1) the measurement of the effective delayed neutron lifetimes, the temperature coefficient of reactivity and the study of possible 'neutron wave' effects; (2) the measurement of neutron age and other spatial parameters by a multi-channel correlation technique.

A block diagram of the recording apparatus is given in Fig. 1. The ionization chamber was placed centrally in the reactor core in a mean thermal neutron flux of $10^9$ neutrons/cm.$^2$/sec. The inherent noise and long-term drift of the electronic circuitry were measured and minimized.

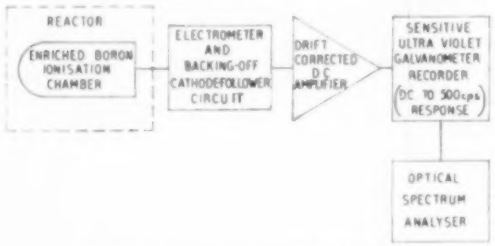

REACTOR
ENRICHED BORON IONISATION CHAMBER
ELECTROMETER AND BACKING-OFF CATHODEFOLLOWER CIRCUIT
DRIFT CORRECTED D.C. AMPLIFIER
SENSITIVE ULTRA VIOLET GALVANOMETER RECORDER (DC TO 500cps RESPONSE)
OPTICAL SPECTRUM ANALYSER

Fig. 1. Equipment for recording and analysis

A sample of the reactor-power random fluctuation is given in Fig. 2. The recording speed of 10 cm. per sec. was found to be most suitable for the measurement of the effective prompt neutron lifetime. The trace was generated by an optical galvanometer reflecting the beam of a mercury arc lamp on to an ultra-violet sensitive paper. This forms an immediately visible semi-permanent record which may be permanently fixed if required. The galvanometer sensitivity was 20 μamp. per mm. of trace reflexion. The investigation is being continued with a fifteen-speed multi-channel recorder and a range of galvanometers of sensitivity as high as 0·03 μamp. and flat frequency responses of 1–500 c.p.s.

Table 1

| Frequency (c.p.s.) | Noise current spectral density (relative values) | Noise power spectral density (relative values) |
|---|---|---|
| 1·06 | 97·2 | 2,332 |
| 2·00 | 102·7 | 2,852 |
| 2·94 | 99·3 | 2,223 |
| 3·88 | 98·3 | 2,294 |
| 4·82 | 66·0 | 1,055 |
| 5·76 | 76·2 | 1,904 |
| 6·70 | 64·8 | 992 |
| 7·63 | 67·7 | 1,158 |
| 8·57 | 56·1 | 709 |
| 9·51 | 53·0 | 753 |
| 10·45 | 38·9 | 335 |
| 11·39 | 51·9 | 870 |
| 12·33 | 41·3 | 363 |

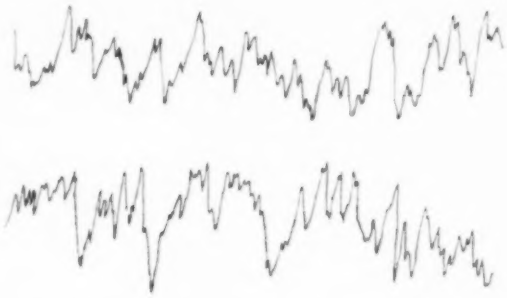


Fig. 2. Time trace of random fluctuation. Recording speed, 10 cm./sec.

The analysis of the time-trace was carried out on the frequency analyser described by Barber *et al.*[2]. Fig. 3 shows a sample of the amplitude spectra obtained. The amplitude spectrum contains sufficient information to plot the reactor transfer function or the power spectral density of the reactor 'noise' (Fig. 4). A typical set of results is given in Table 1.

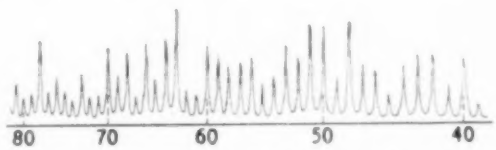



Fig. 3. Amplitude spectrum of random fluctuation, showing peaks from 40th to 80th harmonic of spectrum analyser

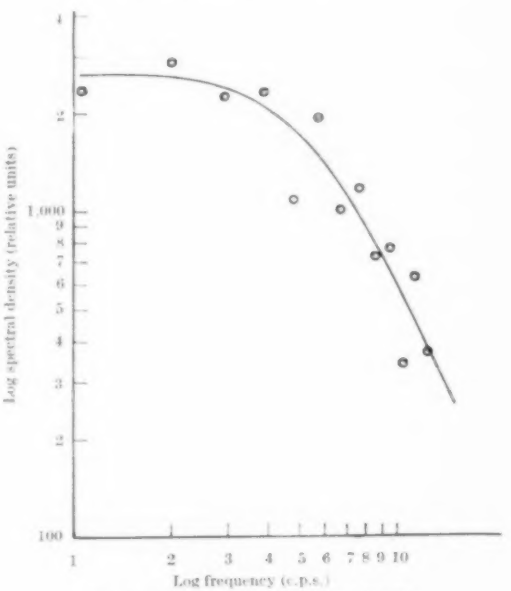



Fig. 4. Random fluctuation spectral density

The effective prompt neutron lifetime in the reactor core was found to be 174 μsec. with an experimental accuracy of 7 per cent. This is consistent with the accuracy of the delayed neutron data available at present. An improvement in accuracy could be obtained by refinements in the electronic circuit and an improvement in the statistics of the analysis through the use of greater lengths of time-trace records. The variation of the neutron lifetime in different parts of the core can be clearly observed with this technique.

A full report will be published elsewhere.

L. G. Kemeny
Samaun

Nuclear Engineering Laboratory,
Queen Mary College,
Mile End Road,
London, E.1.

[1] Moore, M. N., *Nucl. Sci. and Eng.*, **3**, 387 (1958).
[2] Barber, N. F., *et al.*, *Nature*, **158**, 329 (1946).

## Time-dependent Tensile Strength of Solids

Hsaio[1], considering strain-rate effects on polymeric and metallic solids, states that for any given value of strain, the stress obtained at different rates of straining is linearly related to the logarithm of the strain-rate. This is considered to be a basic law which is reasonably safe to apply to a large number of solids. He also presents data for polystyrene showing a linear dependence of fracture stress on the logarithm of strain-rate. These facts are used as evidence supporting certain theories concerning the time-dependence of tensile properties.

The results quoted by Hsaio are confined to a range of two decades of strain-rate in the region of $10^{-5}$ sec.$^{-1}$. In hitherto unpublished work we have measured the tensile properties of isotactic polypropylene (in the form of thin filaments oriented to a draw ratio of about 5·5 : 1) over six decades of strain-rate from $10^{-4}$ to $10^{2}$ sec.$^{-1}$ at 20° C. The dependence of stress at a given strain, and of yield and breaking stress, on the logarithm of strain-rate is shown in Fig. 1. These figures reveal that though the conclusions of Hsaio might be applicable to this material in the range of strain-rates in which he worked, they are certainly inapplicable in a range which extends to higher rates of deformation.

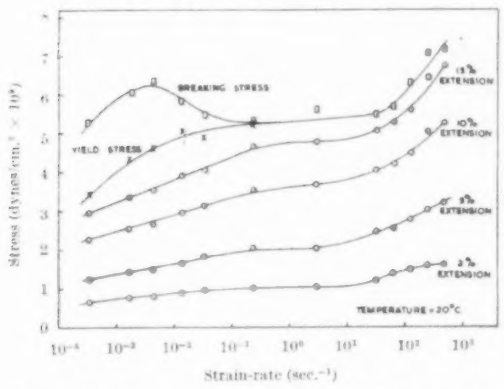



Fig. 1. Effect of strain-rate on tensile properties of oriented isotactic polypropylene

It is intended to publish the full details of this work elsewhere.

I. H. Hall

British Rayon Research Association,
Heald Green Laboratories,
Wythenshawe, Manchester 22.

[1] Hsaio, C. C., *Nature*, **186**, 535 (1960).

## Composition Requirements for Glass Formation in Metallic and Ionic Systems

We have developed in recent papers the point of view that all liquids, ionic and metallic included, would form glasses when sufficiently undercooled, save for the intervention of crystallization[1–3]. We have shown[2] that the glass-forming tendency (for a given rate of cooling and for substances of a given molecular type) is greater the lower is the reduced melting temperature :

$$\tau_m = \frac{kT_m}{h_v} \qquad (1)$$

where $T_m$ is the thermodynamic crystallization temperature, and $h_v$ is the molecular heat of vaporization. This criterion is in semi-quantitative accord with experience on glass formation. In particular it encompasses Zachariasen's[4] criterion, and accounts for the enhancement of glass-forming tendency by molecular asymmetrization, both being simply equivalent to the depression of $\tau_m$. It is also clear, as we pointed out, that the addition of impurities which depress $\tau_m$ similarly enhances the glass-forming tendency. In this communication we point out striking new experimental confirmation of this last deduction.

Klement, Willens and Duwez[5] have recently reported the formation of glass in a gold–silicon alloy containing 25 atomic per cent silicon. This appears to have been the first instance in which a metallic glass was formed by cooling the melt. Glass formation in this experiment was, of course, facilitated by the drastic cooling-rate achieved. However, that the gold–silicon alloy in particular formed a glass is, we believe, a consequence of its low $\tau_m$. The composition of the alloy is near the eutectic (reported[6] to be 31 atom per cent silicon) for which $\tau_m \sim 0{\cdot}015$. Thus its $\tau_m$ and that of neighbouring compositions are low enough for a strong glass-forming tendency to exist. A similar strong tendency toward glass formation should be exhibited by gold–germanium alloys of near eutectic compositions and indeed by any eutectic with a similar pronounced dip in the melting temperature.

We infer from the reported room temperature instability that the glass transition temperature, $\tau_g$ (see ref. 3 for definition), of the gold–silicon alloy is near room temperature, that is, $\tau_g \sim 0{\cdot}007$. This is a much lower glass transition temperature than for other fluid types and is a consequence of the generally higher fluidity of liquid metals.

Another unique feature of the gold–silicon glass is its high stability against crystallization at temperatures much above those at which pure amorphous metal films apparently can crystallize. For example, Hilsch[7] has shown that such films may crystallize at temperatures below 20° K. ($\tau \sim 0{\cdot}001$). The reason for this stability is that, while in the pure material crystallization requires atom motions of less than one

atom diameter, crystallization of a eutectic requires chemical diffusive motion over several atom diameters.

In ionic melts one would expect a similar strong glass-forming tendency in low melting eutectics. This expectation is confirmed by the observations of Dietzel and Poegel[8], who showed that the glass-forming tendency of the calcium nitrate–potassium nitrate system is greatest for solutions of near eutectic composition. J. D. Mackenzie (personal communication) has shown that these solutions are mainly ionic in character.

M. H. Cohen

University of Chicago,
Chicago, Illinois.

D. Turnbull

General Electric Research Laboratory,
Schenectady, New York.

[1] Cohen, M. H., and Turnbull, D., *J. Chem. Phys.*, **31**, 1164 (1959).
[2] Turnbull, D., and Cohen, M. H., *J. Chem. Phys.* (in the press).
[3] Turnbull, D., and Cohen, M. H., "Modern Aspects of the Vitreous State", edit. by Mackenzie, J. D. (Butterworths) (in the press).
[4] Zachariasen, W. H., *J. Amer. Chem. Soc.*, **54**, 3841 (1932).
[5] Klement, W., Willens, R. H., and Duwez, P., *Nature*, **187**, 869 (1960).
[6] Hansen, M., "Aufbau der Zweistofflegierungen" (Springer, Berlin 1936).
[7] Hilsch, R., "Non-Crystalline Solids", edit. by Fréchette, V. D., 348 (J. Wiley and Sons, New York, 1960).
[8] Dietzel, A., and Poegel, H. J., Proc. Intern. Cong. Glass, 3 (Venice, 1953).

## Ultra-Violet Absorption Spectrum of Water

On further examination, the absorption peaks of water recently discussed[1] have been found to be inherent in the instrumental technique used. The fall in the values of optical density at the lower wave-lengths is the normal stray-light effect under these conditions, but the 'fine structure' is now thought to be due to the oxygen absorption in the factory-sealed monochromator and inadequate compensation within the instrument when the slit automatically opens and closes on passing through the wave-lengths at the oxygen absorption peaks.

The water spectrum in the far ultra-violet to 185 mμ as shown by Barrett and Mansell[2] has been confirmed in this Laboratory by a grating instrument (Optika *C.F.*4) which has just been installed.

R. M. Golding

Dominion Laboratory,
Department of Scientific and Industrial Research,
Wellington, New Zealand.

[1] *Nature*, **186**, 308; **187**, 138 (1960).
[2] *Nature*, **187**, 138 (1960).

# METALLURGY

## Microhardness and Other Properties of Magnesium Compounds with the Calcium Fluoride Structure

Relations have previously been proposed[1,2] between hardness and latent heat of fusion, $L_f$, for pure metals. This communication shows that a relation also holds for the series of intermetallic compounds $Mg_2Si$, $Mg_2Sn$ and $Mg_2Pb$, and by using the results for these compounds, $L_f$ for $Mg_2Ge$ is obtained by interpolation.

The four compounds form an isomorphous series from the covalent semiconductor $Mg_2Si$ to the nearly metallic $Mg_2Pb$. On electrochemical grounds the bond-strength, and therefore also the mechanical strengths, would be expected to decrease in the same order. Fig. 1 shows that this is indeed the case for microhardness, while degree of brittleness (as indicated by cracking near the impression) also decreases in this order. Alloys near the composition of the respective phases were melted and slowly cooled to form large idiomorphic grains; the microstructures of the four alloys were remarkably similar. Impressions were made on a freshly polished surface with a diamond pyramid indenter under 50 gm. load. Great care was necessary in the preparation of these surfaces as all the compounds tarnish rapidly in moist air, the rate of attack increasing from $Mg_2Si$ to $Mg_2Pb$.

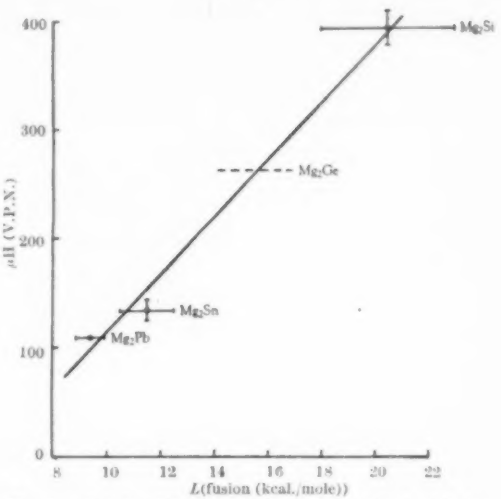



Fig. 1. Relation between microhardness and heat of fusion

In Fig. 1 it may be seen that the hardness-level of $Mg_2Ge$ should intercept the curve at $L_f = 15{\cdot}5$ kcal./mole, and it is suggested that this would be accurate to $\pm$ 1·5 kcal./mole. No data have been found in the literature to verify this value.

That these compounds do in fact form a physico-chemical series is shown by Fig. 2, where the microhardness is seen to be a function of the interatomic distance, $r$, between unlike atoms. The relation is of the form given by Goldschmidt[3]:

$$H = S \cdot \frac{e_A \cdot e_B}{r^m}$$

where $S$ and $m$ are constants, and $e_A$ and $e_B$ the valency of the two atoms. The slope $m$ seems to

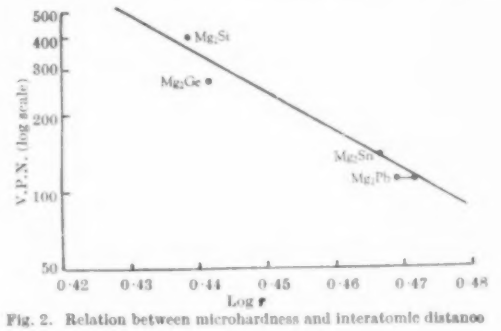



Fig. 2. Relation between microhardness and interatomic distance

Table 1

| Group | m | Ref. |
|---|---|---|
| I–VII (Sodium chloride type) | 5 | 3 |
| IV–IV (Silicon carbide type) | 5 | 4 |
| III–V (Zinc sulphide type) | 9 | 4 |
| III—Transition metals | 11 | 5 |
| II–IV (Calcium fluoride type) | 15 | Present work |

depend on crystal structure and position in the Periodic Table, as is apparent in Table 1. It is hoped that work in hand on a wider range of intermetallic compounds will allow a better understanding of the Goldschmidt rule.

My thanks are due to Mr. R. G. Turner for help with the experimental work, and to Aluminium Laboratories, Ltd., Banbury, for permission to publish this communication.

E. R. Petty

Aluminium Laboratories, Ltd.,
Banbury,
Oxfordshire.

[1] Westbrook, J. H., *Trans. Amer. Soc. Metals*, **45**, 221 (1953).
Osipov, K. A., and Fedotov, S. G., *Izv. Akad. Nauk. S.S.S.R. Otd. Khim. nauk.*, **2**, 98 (1955).
[3] Goldschmidt, V. M., *Skrift. Norske vid-akad., Oslo*, **2** (8), 102 (1926).
[4] Wolff, G. A., Toman, L., Field, N. J., and Clark, J. C, "Semiconductors and Phosphors", Proc. Intern. Colloq., 463 (Garmisch-Partenkirchen, 1956).
[5] Petty, E. R. (to be published).

## ENGINEERING

### Reactions on Metal Surfaces at High Temperatures

In a recent communication in *Nature*[1] reference was made to a technique developed at Thornton Research Centre for investigating high-temperature reactions between metal surfaces and 'extreme-pressure' lubricating oil additives. We should like to take this opportunity of describing briefly the development of the technique and its potentialities.

Extreme-pressure lubricating oil additives, as their name implies, are used in many applications to protect sliding metal surfaces against incipient seizure (scuffing), under conditions of heavy load when normal hydrodynamic lubrication fails. They are generally considered to function[2] by reacting with the metal surfaces in the contact zone, thus interposing a solid film of low shear-strength between the mating surfaces. The stimulus for reaction comes from the local high temperatures generated in the contact area. Extreme-pressure additives vary in their effectiveness, however, and this is due, at least in part, to differences in their reactivities. Investigating such a hypothesis is complicated by the difficulty of measuring the reactivities of relatively unstable additives at temperatures comparable to those generated transiently in practice.

This difficulty was partially overcome by simulating the high metal temperatures in a static system by electrical heating. The principle was simple and merely involved passing a current through a thin metal wire immersed in an oil containing an extreme-pressure additive. Metal temperatures were deduced from the measured resistance/temperature characteristics of the metal. Reaction-rates at various temperatures were followed from the increase in resistance of the wire due to chemical attack by the additive. The method was successful but had one

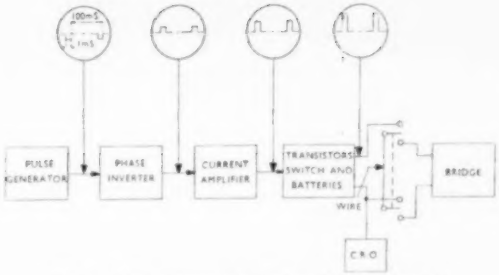



Fig. 1. Block diagram of hot-wire pulsing equipment

limitation: the maximum temperature which could be attained was determined to a large extent by the boiling point of the oil. This meant that maximum temperatures in general were limited to about 600° C., even in oils of high boiling point. This limitation was overcome by passing short pulses of current through the wire. The duration of the pulse was selected so that the fluid surrounding the wire did not vaporize to any appreciable extent during this period. In this way, temperatures up to the melting point of the wire could be easily reached in both volatile and non-volatile solvents. The duration of a single pulse, and hence the minimum reaction period, was $10^{-3}$ sec.

The heart of the system is the electronic device for the generation and control of the pulses. How this was achieved is shown diagrammatically in Fig. 1. Since the voltage across the wire is a square wave, the current wave-form is defined by the increase in resistance of the wire due to its rise in temperature. The current wave-form, observed on a suitable oscilloscope, can thus be used to determine the temperature of the wire. Reactions between additive and metal can be followed by estimating the thickness of reaction product by radiotracer methods, X-ray diffraction, etc., or more simply from increases in resistance of the wire, as mentioned previously. We have used the latter method.

Some results obtained with this pulse technique using a stainless steel wire are shown in Fig. 2. The plot of $\log_{10}$ initial reaction-rate against $1/T$(° K.) is linear and shows clearly the effect of temperature on the reaction-rates. Reactions of carbon tetrachloride (boiling point 77° C.) were as easy to study as those of dibenzyl disulphide in medicinal white oil (boiling point approx. 450–500° C.) The products

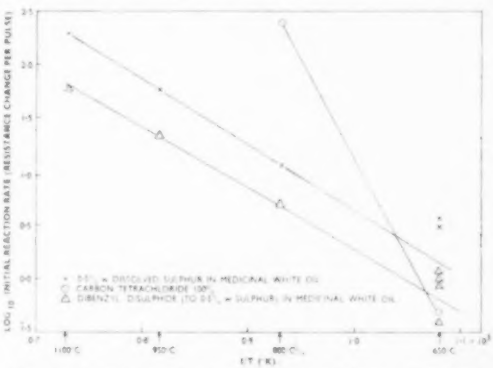



Fig. 2. Reactivity of extreme-pressure additives at different temperatures

of reaction, identified by X-ray diffraction, were: FeS for the sulphur additives and $FeCl_2.4H_2O$ for carbon tetrachloride.

The technique is versatile, rapid and simple to use, and certainly achieves temperatures comparable to those considered to be generated transiently on meshing gear surfaces, for example. These studies of reactions between extreme-pressure additives and metal surfaces at high temperatures are giving us a better understanding of the mechanism of action of extreme-pressure lubricants. A more detailed account will be published elsewhere.

We wish to thank the Directors of "Shell" Research, Ltd., for permission to publish this communication.

F. T. Barcroft
J. R. Hayden

"Shell" Research, Ltd.,
Thornton Research Centre,
P.O. Box 1, Chester.

[1] Campbell, R. B., Grunberg, L., and Scott, H. M., *Nature*, **187**, 588 (1960).
[2] Bowden, F. P., and Tabor, D., "The Friction and Lubrication of Solids" (Clarendon Press, Oxford, 1950).

## CHEMISTRY

### Use of Krypton for Surface Area Measurements

Considerable interest has recently been focused on the suitability of using krypton adsorption isotherms at liquid air temperatures for the determination of the surface area of solids. From the isotherms the monolayer volume, $v_m$, which can be converted to surface area using the effective cross-sectional area of an adsorbed krypton atom, is obtained by the Brunauer–Emmett–Teller method[1]. This method generally yields a linear plot of $p/v(p^0 - p)$ against $p/p^0$ ($v$ = volume adsorbed at an equilibrium krypton pressure, $p$; $p^0$ = s.v.p. of krypton at the adsorption temperature) in the range of relative pressure, $p/p^0$, 0·05–0·35.

Haul[2] considers that krypton is more suitable than nitrogen as adsorbate for measuring small surface areas. Malden and Marsh[3], however, state that nitrogen should be used in preference to krypton as the latter is liable to yield Brunauer–Emmett–Teller plots which are convex to the $p/p^0$ axis. These curved plots greatly reduce the accuracy of the determination of $v_m$. More recently, Gaines and Cannon[4], on the basis of a large number of area determinations and on theoretical grounds, consider that the general applicability of krypton, even for $p/p^0$ ranges extending well below 0·05, has been amply demonstrated. This conclusion is supported by recent work on evaporated iron films[5,6]. Krypton adsorptions on these films at liquid nitrogen temperature yield Brunauer–Emmett–Teller plots which are accurately linear in the $p/p^0$ range $10^{-4}$ to $5 \times 10^{-2}$ and give meaningful $v_m$ values. In the light of the foregoing remarks, the following results may be of interest.

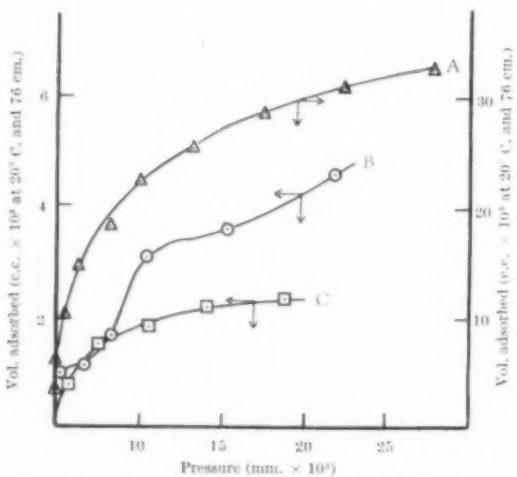



Fig. 1. Krypton adsorption isotherms. *A* (at −193·2° C.), fresh film, $v_m = 33{\cdot}5 \times 10^{-2}$ c.c. at S.T.P.; *B* (at −192·8° C.), sintered film, $v_m = 5{\cdot}24 \times 10^{-2}$ c.c. at S.T.P.; *C* (at −193·0° C.), 'treated' film, $v_m = 2{\cdot}47 \times 10^{-2}$ c.c. at S.T.P.

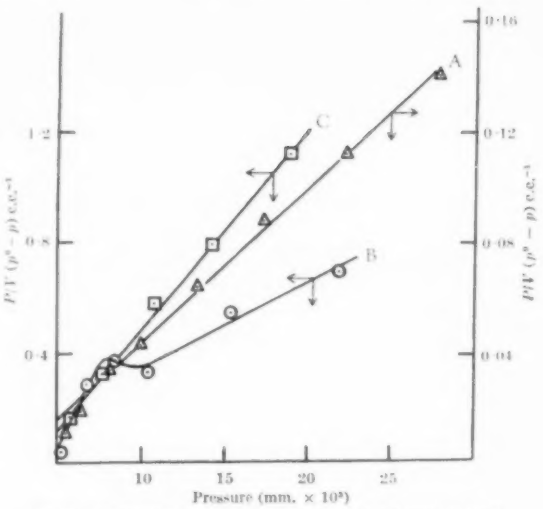



Fig. 2. Brunauer–Emmett–Teller plots from data shown in Fig. 1

A chemically clean silver film was produced in high vacuum ($< 10^{-6}$ mm. mercury) by evaporation on to the walls of a 'Pyrex' vessel the outside temperature of which was kept at −193·3° C. This film, which weighed 10 mgm., gave the familiar σ-shaped krypton adsorption isotherm at −193·2° C. and a linear Brunauer–Emmett–Teller plot (curves *A*, Figs. 1 and 2). Sintering the film at 20° C. for 90 min. caused the shape of the next low-temperature isotherm at −192·8° C. to alter radically (curve *B*, Fig. 1). Moreover, the Brunauer–Emmett–Teller plot is anomalous, being composed of two approximately linear portions separated by a kink (curve *B*, Fig. 2). Curves *C* (Figs. 1 and 2), both of which are normal, were obtained at −193·0° C. after the sintered film had chemisorbed oxygen at temperatures up to 20° C. followed by prolonged pumping (17 hr. at $< 10^{-6}$ mm. mercury) at room temperature.

For the freshly prepared and 'treated' silver surfaces, monolayer volumes deduced from the Brunauer–Emmett–Teller plots in the $p/p^0$ range $5 \times 10^{-4}$ to $5 \times 10^{-2}$ were in good agreement with those estimated roughly from the isotherms (*A* and *C*, Fig. 1). For the sintered silver surface, uncertainty exists as to which of the two straight lines in the Brunauer–Emmett–Teller plot should be taken as the basis for obtaining $v_m$. It does, however, emerge that the

$v_m$ obtained from the slope of the Brunauer–Emmett–Teller straight line at the higher $p/p^0$ range $1 \times 10^{-2}$ to $3{\cdot}4 \times 10^{-3}$ (curve *B*, Fig. 2) agrees to within 25 per cent with the $v_m$ estimated roughly from curve *B*, Fig. 1, on the assumption that adsorption corresponds to monolayer completion at the last recorded pressure.

Other silver films prepared and sintered in the same way as the one described above gave essentially the same results as those shown in Figs. 1 and 2. In all instances, Brunauer–Emmett–Teller plots are anomalous for a freshly sintered surface over the $p/p^0$ range $5 \times 10^{-4}$ to $5 \times 10^{-3}$, at which normal linear Brunauer–Emmett–Teller plots are obtained for a freshly evaporated or 'treated' silver surface.

Anomalous Brunauer–Emmett–Teller plots, similar in shape to those described here, have been reported previously on polycrystalline graphite[7] and, to a smaller degree, on evaporated carbon films[8]. No adequate explanation for such anomalies has yet been found, though it is significant that curve *B*, Fig. 1, suggests that vertical steps in the isotherm, and hence second-order phase changes in the adsorbed film, may be present.

From a practical point of view, however, the occurrence of anomalous krypton Brunauer–Emmett–Teller plots on surfaces which have not chemisorbed any gases but have simply been sintered reduces the power of the krypton adsorption method of measuring small surface areas. A further account of this work will be published elsewhere.

I acknowledge some experimental assistance from K. Syers, a grant from the Chemical Society, London, and the interest of Prof. S. Peat.

JOHN M. THOMAS

Department of Chemistry,
University College of North Wales,
Bangor,
Caernarvonshire.

[1] Brunauer, S., Emmett, P. H., and Teller, E., *J. Amer. Chem. Soc.*, **60**, 309 (1938).
[2] Haul, R. A. W., *Angew. Chem.*, **68**, 238 (1956).
[3] Malden, P. J., and Marsh, J. D. F., *J. Phys. Chem.*, **63**, 1309 (1959).
[4] Gaines, G. L., and Cannon, P., *J. Phys. Chem.*, **64**, 997 (1960).
[5] Roberts, M. W., *Nature*, **182**, 1151, 1205 (1958).
[6] Roberts, M. W., *Trans. Farad. Soc.*, **56**, 128 (1960).
[7] Gulbransen, E. A., and Andrew, K. F., *Indust. Eng. Chem.*, **44**, 1039 (1952).
[8] Sykes, K. W., and Thomas, J. M., Proceedings of the Fourth Carbon Conference, 29 (Pergamon Press, 1960).

## Reaction of Oxygen Atoms with Hydrogen

THE reaction between ground-state oxygen atoms and hydrogen :

$$O(^3P) + H_2 = OH + H\,;\ \Delta H^0 = 0 \text{ kcal./mole} \quad (1)$$

is known to be an elementary process in the branching chain reaction between hydrogen and oxygen, and it is therefore of interest to determine its kinetics. Harteck and Kopsch[1] measured the amounts of water formed in the reaction between hydrogen and electrically discharged oxygen containing about 25 per cent of oxygen atoms at three temperatures between 300° K. and 462° K. From these data an activation energy of $6 \pm 1$ kcal./mole for reaction (1) was computed. However, the formation of water under these conditions may arise not only from reaction (1) followed by reaction (2) :

$$OH + H_2 = H_2O + H\,;\ \Delta H^0 = -13 \text{ kcal./mole} \quad (2)$$

but also from a chain reaction involving molecular oxygen. In the absence of undissociated oxygen, the only secondary reactions to be considered are reactions (2) and (3) :

$$O + OH = O_2 + H\,;\ \Delta H^0 = -14 \text{ kcal./mole} \quad (3)$$

The velocity constant of reaction (2) has been determined as $1{\cdot}2 \times 10^{14} \exp(-10{,}000/RT)$ cm.$^3$ mole$^{-1}$ sec.$^{-1}$ by Avramenko and Lorentso[2], and a value of $k_3 = 2 \times 10^{13} \exp(-2{,}000/RT)$ cm.$^3$ mole$^{-1}$ sec.$^{-1}$ can be obtained from Semenov's value[3] for the rate constant of the reverse reaction and from the calculated equilibrium constant.

There is evidence that $^1D$ oxygen atoms react more rapidly with hydrogen than do $^3P$ ground-state atoms[4–6], and it is also possible that the value of $k_1$ determined by Harteck and Kopsch[1] was affected by the presence of excited atoms in the discharged oxyen.

Oxygen atoms in the absence of molecular oxygen can be produced by addition of nitric oxide to nitrogen atoms in active nitrogen, when the stoichiometric and very rapid reaction (4) occurs[7–9] :

$$N(^4S) + NO(^2\Pi) = N_2(^1\Sigma) + O(^3P)\,;\ \Delta H^0 = -75 \text{ kcal./mole} \quad (4)$$

Tanaka *et al.*[10] have shown that the concentration of excited nitrogen atoms in active nitrogen is about 1/500 of that of ground-state atoms, and the high collision efficiency of reaction (4) (ref. 11) shows that it does not violate the spin correlation rules. It therefore follows from a consideration of the energies of the various electronic states of $N_2$ and O that both these species are formed in their electronic ground-states.

In this work active nitrogen was produced by passing purified nitrogen through an 18 Mc./sec. electrodeless discharge. Nitric oxide was added past the discharge in slight excess (about 5 per cent excess), as shown by the appearance of a weak air afterglow continuum ($NO + O = NO_2 + h\nu$) downstream from the mixing point. The nitrogen, now containing about 0·5 per cent of oxygen atoms, passed through a 21-mm. diameter quartz tube enclosed in a furnace. This tube had four mixing inlets spaced at 30 cm. intervals, through which hydrogen could be introduced[12]. Oxygen atom concentrations in the gas leaving the furnace were determined by measurement of the intensity of the air afterglow produced when known flow-rates of nitric oxide were added 10 cm. upstream from a photomultiplier tube, 30 cm. downstream from the furnace exit. The intensity of the air afterglow is known to be proportional to both oxygen atom and nitric oxide concentrations[12], and this process is unaffected by the presence of hydrogen atoms (unpublished results).

In this system the rate of removal of oxygen atoms by the third-body recombination reactions $O + O + M = O_2 + M$ and $NO + O + M = NO_2 + M$ is much smaller than the rate of reaction of oxygen atoms with hydrogen, and the correction to the data to allow for these reactions was less than 5 per cent. The rate of reaction of oxygen atoms was found to be first order in both oxygen atom and hydrogen molecule concentrations between 409° K. and 733° K. and at total pressures from about 1·5 to 3 mm. mercury. There was no evidence that the reaction-rate depends on total pressure, and the only third-order reaction which could be important in our system :

$$O(^3P) + H_2 + M = H_2O + M$$

has an apparently negligible rate, presumably because it violates the spin correlation rules. In our experiments $k_3(O)$ is always greater than $k_3(H_2)$ or $k_1(H_2)$ and the observed rate constant is therefore $2k_1$. Our results at six temperatures between 409° K. and 733° K. are represented by $k_1 = 1{\cdot}2 \times 10^{13} \exp(-9{,}200/RT)$ cm.$^3$ mole$^{-1}$ sec.$^{-1}$ to within 10 per cent. Measurements of the rate of reaction of oxygen atoms with deuterium are being made by the same technique.

An attempt is being made to investigate the kinetics of reactions (2) and (3) and thus to confirm the results of Avramenko and Lorentso[8], and of Semenov[3].

M. A. A. Clyne
B. A. Thrush

Department of Physical Chemistry,
University of Cambridge.

[1] Harteck, P., and Kopsch, U., *Z. phys. Chem.*, B, **12**, 327 (1931).
[2] Avramenko, L. I., and Lorentso, R. V., *Zh. fiz. khim.*, **24**, 207 (1950).
[3] Semenov, N. N., "Some Problems of Chemical Kinetics and Reactivity", **2**, 47 (Pergamon Press, London, 1959). Karmilova, L. V., Nalbandyan, A. B., and Semenov, N. N., *Zh. fiz. khim.*, **32**, 1193 (1958).
[4] Kistiakowsky, G. B., *J. Amer. Chem. Soc.*, **52**, 1868 (1930).
[5] Bear, R. S., and Eyring, H., *J. Amer. Chem. Soc.*, **56**, 2020 (1934).
[6] Basco, N., and Norrish, R. G. W. (unpublished results).
[7] Kistiakowsky, G. B., and Volpi, G. G., *J. Chem. Phys.*, **27**, 1141 (1957); **28**, 665 (1958).
[8] Kaufman, F., and Kelso, J. R., *J. Chem. Phys.*, **27**, 1209 (1957).
[9] Morgan, J. E., Elias, L., and Schiff, H. I., *J. Chem. Phys.*, **33**, 930 (1960).
[10] Tanaka, Y., Jursa, A., and LeBlanc, F., "The Threshold of Space", edit. by Zelikoff, M., 89 (Pergamon Press, New York, 1957).
[11] Clyne, M. A. A., and Thrush, B. A., *Nature*, [**189**, 56 (1961)].
[12] Clyne, M. A. A., and Thrush, B. A., *Trans. Farad. Soc.*, **57**, 69 (1961).
[13] Kaufman, F., *Proc. Roy. Soc.*, A, **247**, 123 (1958).

## Origin of Some Primary Coal Tar Components

The presence in the ether-, chloroform- or light petroleum-soluble portions of extracts from bituminous coals of paraffinic, alicyclic and alkylated aromatic hydrocarbons was demonstrated between 1910 and 1920[1–5]. Pictet and Bouvier first showed the presence of similar compounds in a vacuum tar[6], while Jones and Wheeler found the pyridine-soluble, chloroform-soluble extract of a bituminous coal to be the main source of hydrocarbons and resins, the former being characterized as paraffins, olefins and naphthalenes[4].

On the basis of a review of the literature, Dryden and others[7] contended, unlike me[8], that no tar was really primary in the sense that it contained materials related structurally to the coal, but that small, reactive fragments were first formed by pyrolysis, which built up to the more complex constituents of a tar. A 'primary' tar was one only in the sense that it contained substances formed by a relatively simple sequence of reactions. Subsequent experimental work carried out by this school, from which resemblances were found between chloroform extracts of coals heated to the plastic range and the volatile products of their vacuum pyrolysis, appears to have modified their original view. The existence of relatively primary pyrolysis products is now admitted[9], but the techniques they used did not result in the separation of hydrocarbons, and the hypothesis was put forward that these pyrolysis products were formed entirely by depolymerization of the coal.

A recent mass spectrometric study of coal vitrains by Holden and Robb confirms the earlier views that hydrocarbons contained in the coal are distilled off on heating, for the following were evolved before the main decomposition had set in: aliphatics of molecular weight 200–350, containing much cyclic material; and alkyl aromatics, including alkyl-substituted benzenes, naphthalenes and higher members. These compounds were thought to be bound in the coal in a loose, physical way, rather than chemically, and to be similar to those from chloroform-soluble extracts of coals[10].

It must, therefore, be taken as established that primary tars contain similar compounds to coal extracts containing lower molecular weight material. It has not been shown, however, how close is this relationship, qualitatively and quantitatively.

I have shown that four broad fractions were invariably present in the neutral, light petroleum-soluble portions of primary tars made from coals of low rank[11]. Their separation was later standardized as part of a method of analysis of tars based on solvent extraction and chromatography[12]. Preliminary qualitative work is here reported, undertaken to establish whether similar fractions were present in a bituminous coal as in the primary tar derived from it.

The tar was made by internal heating with hot gas of the coal[13] (Thoresby coal: orthohydrous, weakly caking, high-volatile bituminous). The neutral, benzene-soluble, light petroleum (40–60°)-soluble portion was subdivided by adsorption chromatography on silica gel with eluants in the following

Table 1. Comparison of Fractions from Coal Extract and Coal Tar

| Fraction | | Description applying to each pair of fractions | % yield on dry extract or tar | % yield on dry, ash-free coal | Predominant chemical types found in coal tar fractions, *b* | % C | % H | %(O +) | C/H | Molecular weight | $n_D^{20}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | *a* | White, soft wax, consisting of mixture of oils and waxes | 4·13 | 0·14 | *n*-, *cyclo*- and *iso*-paraffins; highly alkylated benzenes | 86·0 | 13·9 | 0·1 | 0·51 | 240 | 1·474 (25°) |
| | *b* | | 6·75 | 0·61 | | 85·3 | 13·6 | 1·1 | 0·52 | 240 | 1·458 (25°) |
| 2 | *a* | Yellow, mobile oil | 3·09 | 0·11 | Alkylated hydronaphthalenes | 87·7 | 11·8 | 0·5 | 0·62 | 240 | 1·534 |
| | *b* | | 13·43 | 1·21 | | 87·2 | 11·0 | 1·8 | 0·66 | 220 | 1·525 |
| 3 | *a* | Dark brown, viscous oil | 17·32 | 0·61 | Alkylated polycyclics, mainly naphthalenes | 90·6 | 8·9 | 0·5 | 0·85 | 220 | 1·613 |
| | *b* | | 20·57 | 1·85 | | 87·5 | 8·3 | 4·2 | 0·88 | 230 | 1·610 |
| 4 | *a* | Dark brown, semi-solid, with characteristic odour | 4·74 | 0·17 | Complex mixture of oxygenated aromatic compounds | 77·2 | 9·0 | 13·8 | 0·72 | 360 | — |
| | *b* | | 5·02 | 0·45 | | 77·2 | 8·4 | 14·4 | 0·77 | 325 | — |

*a*, Coal extract fraction; *b*, coal tar fraction; (O +), oxygen and other elements by difference.

order: light petroleum (40–60°) (two fractions, the first non-fluorescent, the second fluorescent in ultraviolet light); benzene (one fraction); and ethanol (one fraction)[12]. Work is in progress on the characterization of these fractions, part of which has been published[14].

The same coal, sized between ¼ and ½ in. screens, was extracted with a benzene–ethanol mixture (70–30) for more than 50 hr. in a large Soxhlet apparatus until the percolate was virtually colourless. The yield of extract was 3·19 per cent on the coal, air-dried basis, equivalent to 3·50 per cent on the dry, ash-free basis. It is realized that these extractions were incomplete, but the method used enabled material to be obtained in sufficient quantity for a qualitative evaluation. The neutral, light petroleum-soluble portion of this extract, obtained by exhaustive extraction, was similarly subdivided by chromatography.

Table 1 gives data for the chromatographic fractions from both the coal and the coal tar. The similarity between the corresponding pairs of fractions in chromatographic behaviour, appearance, analysis and physical properties is striking. The yields of the coal extract components are less in each case than the corresponding ones from the coal tar.

The oxygen contents of all the coal tar fractions are higher than those from the coal, presumably due to the greater oxidation occurring during preparation and storage of the tar. The infra-red absorption spectra of the two fractions 4 have been found to be almost identical, both indicating the presence of free and chelated OH, aromatic structures and much alkylation. These two fractions oxidize and polymerize readily; thus, the molecular weight of that from the coal increased from 360 to 520 after storage for a few months.

This preliminary work has shown that an important part of the simpler, neutral constituents of a primary tar exists as such in the original coal. It still remains to be shown whether completer extraction of the coal will account for the whole of the remainder of the neutral, light petroleum-soluble constituents of the tar, or whether part of the latter is formed by decomposition of the coal.

I wish to thank Mrs. A. Sen Gupta and G. V. Blunt for help with the experimental work.

M. Vahrman

Department of Pure and Applied Chemistry,
Northampton College of Advanced Technology,
St. John Street,
London, E.C.1.

[1] Pictet, A., and Ramseyer, L., *Ber.*, **44**, 2486 (1911).
[2] Pictet, A., Ramseyer, L., and Kaiser, O., *C.R. Acad. Sci., Paris*, **163**, 358 (1916).
[3] Pictet, A., and Kaiser, O., *Chem. Z.*, **40**, 211 (1916).
[4] Jones, D. T., and Wheeler, R. V., *J. Chem. Soc.*, **107**, 1318 (1915).
[5] Hofmann, F., and Damm, P., *Brennstoff-Chem.*, **3**, 73, 81 (1922); **4**, 65 (1923).
[6] Pictet, A., and Bouvier, M., *C.R. Acad. Sci., Paris*, **157**, 779, 1436 (1913); **160**, 629 (1915); *Ber.*, **46**, 3542 (1913); *Chem. Z.*, **38**, 1025 (1915).
[7] Billington, A. H., Dryden, I. G. C., and Napier, D. H., *B.C.U.R.A. Mon. Bull.*, **16**, 258 (1952).
[8] Vahrman, M., *J. App. Chem.*, **2**, 532 (1952).
[9] Brown, J. K., Dryden, I. G. C., Dunevein, D. H., Joy, W. K., and Pankhurst, K. S., *J. Inst. Fuel*, **31**, 259 (1958).
[10] Holden, H. W., and Robb, J. C., *Fuel*, **39**, 39 (1960).
[11] Vahrman, M., *Chem. and Indust.*, 1125 (1959).
[12] Blunt, G. V., and Vahrman, M., *J. Inst. Fuel*, **33**, 522 (1960).
[13] *Coke and Gas*, **16**, 383 (1954).
[14] Hunter, K. J., and Vahrman, M., *J. App. Chem.*, **10**, 128 (1960).

## Organic Halides as Electron Acceptors in Charge Transfer Compounds

In the literature several indications of the existence of directed chemical bonds between organic halogen compounds and molecules containing atoms like nitrogen, oxygen or sulphur may be found. Results arrived at during the past few years concerning the structure of addition compounds formed by halogen molecules and molecules of the latter type[1] made it appear desirable to determine the structures also of molecular compounds formed by halides.

X-ray crystallographic structure determinations have been undertaken in this laboratory of a series of solid addition compounds between electron acceptors, like iodoform or oxalyl chloride (bromide), and electron-donating molecules like dioxan, dithiane, amines and sulphur. It soon became clear that iodoform preferably makes use of the iodine atoms for the bonding to the atoms of the partner molecule exhibiting electron-donor properties. Furthermore, it appeared that the atomic arrangement—donor atom–halogen–carbon—is at least approximately linear. In some instances the bond formation results in chains extending through the entire crystal of alternating donor and acceptor molecules (for example, in dithiane-iodoform and dioxan-oxalyl halide).

Often the charge-transfer bonds are evidently very weak. Until now we had no proof of carbon–halogen distances differing from the corresponding ones in the free acceptor molecule, similar to the increase in the halogen–halogen distance observed in many addition compounds where a halogen molecule acts as the acceptor[1].

The bond distance halogen–donor atom is shorter in general than the corresponding sum of the accepted van der Waals radii, but the shortening is in some cases rather small (O—Cl, O—Br).

Representative donor–acceptor distances observed are listed in Table 1 and compared with the corresponding van der Waals values[2]. The figures given may be subject to some, but not significant, corrections after further refinements of the respective structures.

Table 1

| Compound | Donor–acceptor | Donor–acceptor distance (Å.) | Sum of van der Waals radii (Å.) (ref. 2) |
|---|---|---|---|
| Quinoline-iodoform (3 : 1)[7] | N—I | 2·99 | 3·65 |
| $S_8$-iodoform (3 : 1)[8] | S—I | 3·44 | 4·00 |
| Dithiane-iodoform (1 : 1)[8] | S—I | 3·29 | 4·00 |
| Dioxan-oxalyl chloride (1 : 1)[9] | O—Cl | 3·18 | 3·20 |
| Dioxan-oxalyl bromide (1 : 1)[9] | O—Br | 3·21 | 3·35 |

Molecules containing both donor and acceptor atoms would be expected to crystallize by forming charge-transfer bonds between the molecules. This is certainly the case in solid cyanogen bromide and iodide. Crystals of these compounds have been shown[3,4] to contain linear arrangements —Hal–C–N Hal–C–N—. The structure determinations do not allow exact bond distances to be given. The chains, however, are directed along crystallographic axes and some conclusions may therefore be drawn from the observed lattice constants. If it may be assumed that the Hal–C and C–N distances do not differ significantly from the distances found in the free

molecules (microwave measurements[5,6]), it follows that the Hal—N distances are equal to, or shorter than, 2·85 Å. (Br) and 2·80 Å. (I), with an uncertainty probably not exceeding 0·1 Å. Neutron diffraction studies of the cyanogen halides are being planned.

T. Bjorvatten
O. Hassel
Chr. Romming

Department of Chemistry,
University of Oslo.

[1] Hassel, O., *et al.*, *Acta Chem. Scand.*, **8**, 873 (1954); **10**, 138, 139 696 (1956); **13**, 268, 275, 1775 (1959); **14**, 391 (1960).
[2] Pauling, L., "Nature of the Chemical Bond" (Cornell University Press, New York, 1960).
[3] Geller, S., and Schawlow, A. L., *J. Chem. Phys.*, **23**, 779 (1955).
[4] Ketelaar, J. A. A., and Zwartsenberg, J. W., *Rec. Trav. Chim.*, **58** 448 (1939).
[5] Smith, A. G., Ring, H., Smith, W. V., and Gordy, W., *Phys. Rev.*, **74**, 370 (1948).
[6] Townes, C. H., Holden, A. N., and Merritt, F. R., *Phys. Rev.*, **74**, 1113 (1948).
[7] Bjorvatten, T., and Hassel, O., *Acta Chem. Scand.*, **13**, 1261 (1959).
[8] *Acta Chem. Scand.* (to be published).

## BIOCHEMISTRY

### Enzymic Synthesis of 3-*O*-α-D-Glucopyranosyl D-Xylose

Transglycosylation reactions with microbial enzymes offer a facile method for the synthesis of new oligosaccharides. Following our earlier report[1] on the production of 3-*O*-β-D-glucopyranosyl D-xylose by the action of a cell-free extract of *A. niger* 152 on a cellobiose–xylose mixture, the corresponding disaccharide containing an α-glucosidic linkage has now been synthesized via the following reaction:

maltose + xylose → 3-*O*-α-glucosyl-xylose + glucose

catalysed by a transglycosylase from *Penicillium lilacinum*.

Mycelia of *Penicillium lilacinum* grown on mineral media (magnesium sulphate heptahydrate 0·074 gm., ammonium nitrate 0·1 gm., potassium dihydrogen phosphate 0·139 gm. and sodium chloride 0·001 gm. in water, 300 ml.) containing maltose (50 gm.) were harvested, washed, shredded in an Atomix and freeze-dried. A cell-free enzyme extract (3·5 gm.) prepared by disintegration of an aqueous suspension of the cells in a Mickle tissue disintegrator was incubated at 30° for 5 days with a sterile aqueous solution (150 ml.) of maltose (30 gm.) and xylose (15 gm.). After arresting enzyme action, the mixture of sugars formed was separated by chromatography on sheets of Whatman No. 3 irrigated with the organic phase of a butanol/ethanol/water (4 : 1 : 5) mixture. The band $R_{maltose}$ 1·75 suspected to contain a reducing glucosyl–xylose was eluted and freeze-dried. Acidic hydrolysis (2 *N* sulphuric acid at 100° for 2 hr.) and paper chromatographic analysis of the hydrolysate confirmed the presence of glucose and xylose in the new component and its disaccharide character was established from the mobility[2] (*M* 0·8) of its *N*-benzylglycosylammonium ion. Reduction of the disaccharide (2 mgm.) with sodium borohydride (2 mgm.) and acid hydrolysis of the resulting disaccharide alcohol yielded a mixture of glucose and xylitol. Hence the disaccharide must have been a glucosyl–xylose. Its optical rotation ($[\alpha]_D^{25}$ + 87·5°, conc., 0·70 in water) and the presence of an absorption peak at 850 cm.$^{-1}$ in its infra-red spectrum established[3] that the glucosidic linkage was of the α-type. The instability to alkali of the disaccharide and the ionophoretic mobility of its borate complex[4] ($M_G$ 0·68–0·70) both suggested that the junction of the two monosaccharide units was 1 → 3. Furthermore, the positive reaction of the disaccharide with the triphenyltetrazolium chloride reagent[5] ruled out a linkage of the 1 → 2 type. The disaccharide (9 mgm.) was treated with 4 per cent methanolic hydrogen chloride (0·5 ml.) at room temperature for 1½ hr. and the resulting methyl furanosides (6·5 mgm.; $[\alpha]_D^{25}$ + 74°, conc., 0·3 in water) isolated. Treatment with sodium metaperiodate (10 mgm. in 2 ml. water) at room temperature for 36 hr., followed by addition of ethylene glycol (0·1 ml.), freeze-drying and passage down a column (15 × 1 cm.) of 'Ultrasorb', gave the salt-free periodate oxidized product (3 mgm.). Reduction of this with sodium borohydride (4 mgm.) yielded a polyalcohol containing an intact xylosyl moiety. This was demonstrated by acidic hydrolysis (*N* hydrochloric acid at 100° for 1 hr.) to yield xylose, characterized by the identity of its infra-red spectrum with that of an equilibrium mixture of an authentic specimen of D-xylose. This last experiment confirmed that the xylose moiety was linked through the 3 position and that the enzymatically synthesized disaccharide was 3-*O*-α-D-glucopyranosyl D-xylose.

One of us (D. B. E. S.) thanks the University of Birmingham for the award of a scholarship.

S. A. Barker
M. Stacey
D. B. E. Stroud

Chemistry Department,
The University,
Birmingham, 15.

[1] Barker, S. A., Bourne, E. J., Hewitt, G. C., and Stacey, M., *J. Chem. Soc.*, 3541 (1957).
[2] Barker, S. A., Bourne, E. J., Grant, P. M., and Stacey, M., *J. Chem. Soc.*, 2067 (1957).
[3] Barker, S. A., Bourne, E. J., Stacey, M., and Whiffen, D. H., *J. Chem. Soc.*, 171 (1954).
[4] Foster, A. B., *J. Chem. Soc.*, 982 (1953).
[5] Feingold, D. S., Avigad, G., and Hestrin, S., *Biochem. J.*, **64**, 351 (1956).

### Applicability of Hydroxocobalamin as a Long-acting Vitamin B12

The main difficulty in the treatment of vitamin $B_{12}$ deficiencies has been that small doses of cyanocobalamin are inadequate to replenish the body's depleted stores and that most of the large parenteral doses are eliminated in the urine within the first 12 hr.

Consequently, attempts have been made to develop a long-acting vitamin $B_{12}$ which could be retained in the body more efficiently than cyanocobalamin[1] by combining it with sesame oil and aluminium monostearate or by making it into a zinc–tannate complex[2].

In the search for a long-acting $B_{12}$ preparation, we screened cobalamins in various media and in various modifications. In these investigations, which will be reported in detail elsewhere[3], only an aqueous solution of hydroxocobalamin (kindly supplied by Dr. Nathaniel S. Ritter, of the Merck Sharp and Dohme Research Laboratories, Division of Merck and Co., Inc., Rahway, N.J.) was found to possess all the features sought for in a long-acting vitamin $B_{12}$.

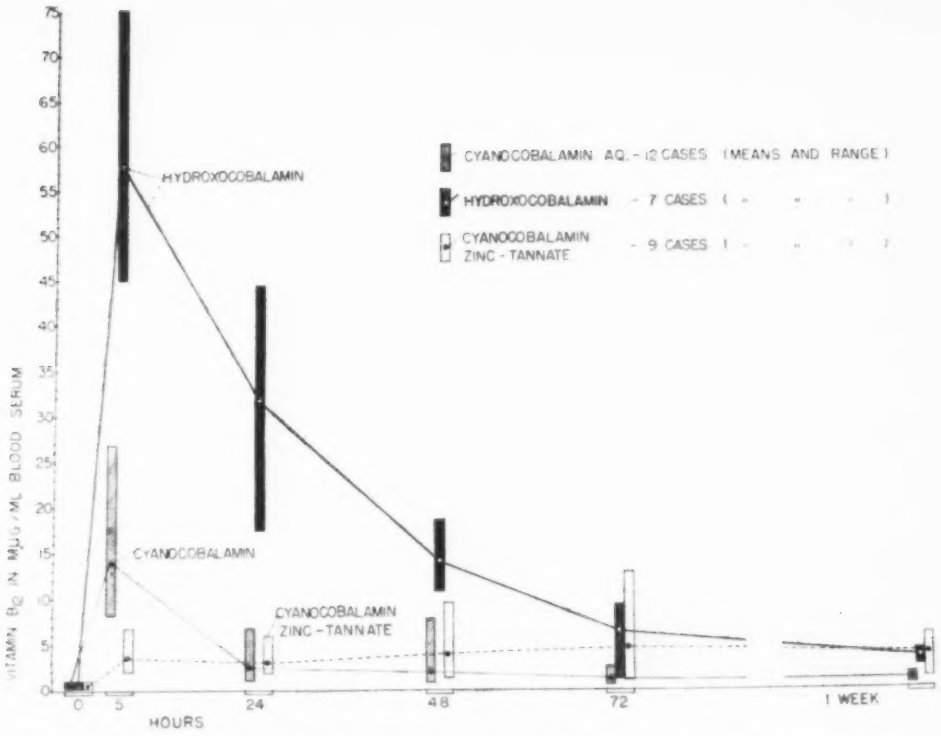



Fig. 1. Vitamin $B_{12}$-levels in blood serum following intramuscular injection of 1,000 μgm. cyanocobalamin, hydroxocobalamin and cyanocobalamin zinc-tannate

Since hydroxocobalamin (formerly known as vitamin $B_{12a}$ and $B_{12b}$) exerts a haematopoietic activity approximately equivalent to that of cyanocobalamin in man[4], we made a detailed study of its absorption, deposition and excretion, and summarize here some of the results obtained.

Seventeen patients with normal $B_{12}$-levels in the blood and no evidence of circulatory or renal failure received hydroxocobalamin in aqueous solution; nineteen, cyanocobalamin in aqueous solution; and seventeen, cyanocobalamin zinc-tannate complex. These materials were injected in a single dose of 500 or 1,000 μgm. Blood was withdrawn, just prior to injection, and at frequent intervals afterwards.

Specimens of urine were collected during the three days after injection. In addition, 24-hr. urine specimens were obtained on the seventh, fourteenth, twenty-first and twenty-eighth days following injection. Determination of the total vitamin $B_{12}$ values in blood serum and urine was made by *Lactobacillus leichmannii* assay[5]. In addition, six patients received alternate intramuscular injections of radioactive cyanocobalamin and hydroxocobalamin labelled with cobalt-57 and -58. For two weeks after injection, the sites of injection and several cutaneous projections of the liver were scanned for radioactivity[6] by means of a scintillation detector and gamma spectrometer.

It was found that a single intramuscular injection of 1,000 μgm. hydroxocobalamin results in an average 96-fold rise in the vitamin $B_{12}$-level in blood serum by the fifth hour, a 52-fold rise by the twenty-fourth hour, a 23-fold rise by the forty-eighth hour and a 10-fold rise by the seventy-second hour. For a 3-week period, the levels of $B_{12}$ in the blood serum were significantly higher, statistically, after intramuscular injection of a single dose of 1,000 μgm. of hydroxocobalamin than after an identical dose of cyanocobalamin. While the initial levels in the blood did not show any statistically significant difference, the mean levels were 1·8 and 4·1 times higher, respectively, 5 hr. after injection of 500 or 1,000 μgm. of hydroxocobalamin, 4·6 and 12·8 times higher by the twenty-fourth hour, 2·4 and 5·2 times higher by the seventy-second hour, and 1·6 and 2·5 times higher by the second to fourth week, than after administration of identical doses of cyanocobalamin (Fig. 1). These differences were highly significant statistically, the $P$ value in all instances being less than 0·001.

Compared with identical doses of cyanocobalamin zinc-tannate complex, the mean levels in blood following intramuscular administration of 1,000 μgm. of hydroxocobalamin were 15·5 times higher by the fifth hour, 10·8 times higher by the twenty-fourth hour and 3·6 times higher by the forty-eighth hour (Fig. 1). Statistically, these differences were highly significant.

Study of the urinary excretion of vitamin $B_{12}$ following administration of cyanocobalamin and hydroxocobalamin showed that aqueous hydroxocobalamin was excreted in the urine much less rapidly than aqueous cyanocobalamin. After a single intramuscular injection of 500 or 1,000 μgm. hydroxocobalamin, only 16 and 27 per cent, respectively, are

lost in the 72-hr. urines, while the corresponding losses of cyanocobalamin at equal doses and time-intervals amount to 60 and 69 per cent, respectively, of the amount injected.

Absorption of radioactive hydroxocobalamin from the site of injection is much slower than that of an aqueous solution of radioactive cyanocobalamin. Comparative studies of six individuals injected on opposite sides of the body with both materials indicate that, by 24 hr., only 0·7–2·0 per cent (and after 6 days, only 0·5–1·0 per cent) of the cyanocobalamin injected remains at the site of injection, whereas after the same time-interval, 6·0–12·0 per cent and 2·5–4·0 per cent, respectively, of the hydroxocobalamin can still be traced at the injection site. At the end of the 7–14-day interval, the hepatic deposition of radioactive hydroxocobalamin was the same as, or slightly higher than, that following injection of an equivalent dose of radioactive cyanocobalamin in the same patient.

Why hydroxocobalamin is absorbed slowly from the site of injection, why it is retained for a longer period in the body and builds up consistently high $B_{12}$-levels in the blood, may be explained by its greater reactivity and the formation of stronger bonds with substances in the body which bind $B_{12}$. This might have been suggested by the results of previous investigations into the binding of hydroxocobalamin to serum proteins[7].

The activity of hydroxocobalamin in its native state, and the higher levels at which it is maintained in the blood, make it a more desirable source of vitamin $B_{12}$ for human use than artificial cyanocobalamin complex depot preparations. Moreover, since the equivalence of the haematopoietic effect of hydroxocobalamin to that of cyanocobalamin has been established[4], and its more effective retention by the body, at consistently higher levels in the blood, has been demonstrated, cogent arguments exist in support of the claim of the superiority of hydroxocobalamin over cyanocobalamin for the treatment of vitamin $B_{12}$ deficiencies.

G. B. J. Glass
H. R. Skeggs
D. H. Lee
E. L. Jones
W. W. Hardy

Department of Medicine,
New York Medical College,
Bird S. Coler Memorial Hospital,
New York,
and
Merck Sharp and Dohme Research Laboratories,
Merck and Co., Inc.,
West Point,
Pennsylvania.

[1] Beard, M. F., and LaRaw, E., Proc. Internat. Soc. Hematology, Sixth Congress, Boston, 426 (abstr.) (1956).
[2] Arnold, A., Berbian, D. A., and Sobell, S. D., *Amer. Pract. Digest of Treatment*, **9**, 1835 (1958). O'Connor, J. S., Davis, R. L., Langworthy, O. R., and Chow, B. F., *Fed. Proc.*, **17**, 528 (1958).
[3] Glass, G. B. J., Skeggs, H. R., Lee, D. H., Jones, E. L., and Hardy, W. W., *Blood* (submitted for publication).
[4] Lichtman, H., Watson, J., Ginsberg, V., Pierce, J. V., Stokstad, E. L. R., and Jukes, T. H., *Proc. Soc. Exp. Biol. and Med.*, **72**, 643 (1949). Schilling, R. F., Harris, J. W., and Castle, W. B., *Blood*, **6**, 228 (1951).
[5] Skeggs, H. R., Nepple, K. M., Valentik, K. A., Huff, J. W., and Wright, L. D., *J. Biol. Chem.*, **184**, 211 (1950).
[6] Glass, G. B. J., Boyd, L. J., and Gellin, G. A., *Blood*, **10**, 95 (1955).
[7] Miller, A., and Sullivan, J. F., *J. Clin. Invest.*, **37**, 917 (1958). Bauriedel, W. R., Picken, jun., J. C., and Underkofler, L. A., *Proc. Soc. Exp. Biol. Med.*, **91**, 377 (1956).

## Later Stages of Protein Synthesis and the Role of Phospholipids in the Process

Recent work in our laboratory[1,2] has shown that lipo-amino-acid complexes are rapidly formed from amino-acids by protoplasts of *B. megaterium*, and further that these complexes have many of the properties to be expected of intermediates in protein biosynthesis. Related studies have also been reported by other workers[3–5]. We have also found that the membrane complex derived by lysis of the same protoplasts under defined conditions contains the complete apparatus of protein biosynthesis[6]. A more detailed examination[7] of this membrane complex has now shown that the bulk of the labelled protein formed after very short periods of incubation of the complex with labelled amino-acids (even a few seconds) is distributed between a phospholipoprotein fraction and ribosomal particles. However, the greater part of the labelled protein is found on the phospholipoprotein fraction, and detailed kinetic experiments[7] carried out with both whole protoplasts and the membrane complex indicate that this is both the main site of initial protein formation and that the protein formed in this fraction is passed on to form soluble protein. In this connexion, it is noteworthy that Dr. P. N. Campbell (personal communication) has evidence indicating that serum albumin synthesized in microsomes of rat-liver is formed on the membrane rather than the ribosomal component of the microsome, and it has been reported[8] that a highly labelled phospholipoprotein is rapidly formed from leucine labelled with carbon-14 by 'ribosomes' from pea-seedling cells.

On the other hand, the evidence that ribonucleic acid (RNA) plays an active part in protein biosynthesis is overwhelming, and it is the purpose of this communication to provide a hypothesis whereby these surprising results may be reconciled with current ideas on the mechanism of protein biosynthesis as outlined by Zamecnik[9] and others. After the initial stage of amino-acid activation, it seems probable from recent work[10] that there exists one RNA of low molecular weight (S-RNA) that acts as a specific receptor for each activated amino-acid, and it further seems likely[11,12] that the S-RNA–amino-acid complexes formed are transferred to an RNA molecule of high molecular weight. This RNA of higher molecular weight can be obtained in the ribosomal particles after suitable cellular fractionation has been carried out, but the work of Hanzon, Hermodsson and Toschi[13] indicates that this RNA may exist in the cell in a more extended form, a conclusion consistent with our own findings in *B. megaterium*[7]. However, for simplicity, it will be referred to here as ribosomal RNA.

The triplet hypothesis of Crick, Griffith and Orgel[14] provides a mechanism whereby the ribosomal RNA can bind and distinguish between the different S-RNA–amino-acid complexes; but a difficulty has been that the S-RNA molecules appear to be too long and complex to serve in their entirety as suitable transfer agents. However, it must be pointed out that this difficulty arises solely because it has been thought that the protein is first formed along the surface of the ribosomal RNA. If, instead, the protein is first synthesized along a phospholipid surface, this difficulty does not arise. We should like to suggest the following possibilities:

(1) That all the S-RNA chains have the same length from the point of triplet attachment to the amino-acid moiety at the end of the chain.

(2) That a phospholipid chain (presumably a phospholipoprotein membrane in most cases) is sited at a distance equal to this length from the ribosomal RNA.

(3) That the amino-groups of the amino-acid moieties can thus each make contact with only one phosphate group of the phospholipid chain. Therefore, although the phospholipid molecules themselves need possess no specificity, the sequence determined by the specific triplet attachment of the two types of RNA molecule is reproduced exactly on the phospholipid chain.

(4) That the further formation of lipo-amino-acid complexes and their condensation along the phospholipid chain to form phospholipoprotein proceed spontaneously, catalysed by the proximity of the charged phosphate groups. The structure of the whole proposed 'template' is illustrated roughly in Fig. 1, although the surfaces represented as straight lines may obviously be helical in form.

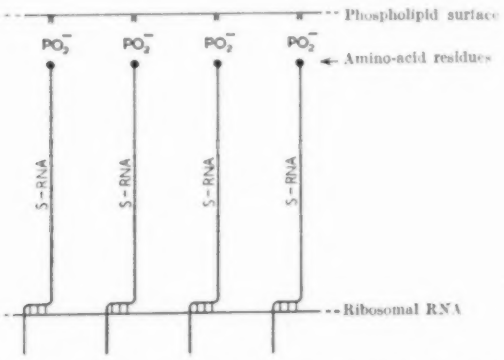



Fig. 1. Outline of structure of proposed 'template' for protein biosynthesis

In support of these suggestions, it may be pointed out that ribosomal particles prepared by detergent methods likely to remove the bulk of the lipid never seem to have activity at all comparable with, for example, pea-seedling ribosomes which apparently retain associated phospholipid[9]. Experiments *in vitro*, such as those carried out by McQuillen, Roberts and Britten[15], often seem to provide evidence that protein attached to the ribosomal RNA itself is labelled first. However, often phospholipoprotein surfaces would be destroyed by the methods of degradation used, or the material from them bound to the ribosomes themselves. The experiments of Zillig and his co-workers[16,17] in *E. coli* have indeed indicated that a lipoprotein membrane fraction (containing some RNA) is a much more active site of protein synthesis than free ribosomal particles obtained in the same experiments.

We wish to express our appreciation to Prof. J. A. V. Butler and Dr. K. S. Kirby for stimulating discussions.

This investigation was supported by grants to the Chester Beatty Research Institute (Institute of Cancer Research: Royal Cancer Hospital) from the Medical Research Council, the British Empire Cancer Campaign, the Jane Coffin Childs Memorial Fund for Medical Research, the Anna Fuller Fund and the National Cancer Institute of the National Institutes of Health, U.S. Public Health Service.

G. D. Hunter
G. N. Godson

Chester Beatty Research Institute,
Institute of Cancer Research:
Royal Cancer Hospital,
Fulham Road,
London, S.W.3.

[1] Hunter, G. D., and Goodsall, R. A., *Biochem. J.*, **74**, 30*P* (1960).
[2] Hunter, G. D., and Goodsall, R. A., *Biochem. J.* (in the press).
[3] Hendler, R. W., *J. Biol. Chem.*, **234**, 1466 (1959).
[4] Gaby, W. L., Naughten, R. N., and Logan, C., *Arch. Biochem. Biophys.*, **82**, 34 (1959).
[5] Gaby, W. L., and Silverman, R., *Arch. Biochem. Biophys.*, **87**, 188 (1960).
[6] Hunter, G. D., Brookes, P., Crathorn, A. R., and Butler, J. A. V., *Biochem. J.*, **73**, 369 (1959).
[7] Godson, G. N., Hunter, G. D., and Butler, J. A. V. (in preparation).
[8] Ts'O, P. O. P., and Sato, C. S., *J. Biophys. Biochem. Cytol.*, **5**, 59 (1959).
[9] Zamecnik, P. C., "Harvey Lectures", **54**, 256 (Academic Press, Inc., 1960).
[10] Zamecnik, P. C., Stephenson, M. L., and Scott, J. F., *Proc. U.S. Nat. Acad. Sci.*, **46**, 811 (1960).
[11] Bosch, L., Bloemendal, H., and Sluyser, M., *Biochim. Biophys. Acta*, **41**, 444 (1960).
[12] Bloemendal, H., Bosch, L., and Sluyser, M., *Biochim. Biophys. Acta*, **41**, 454 (1960).
[13] Hanzon, V., Hermodsson, L. H., and Toschi, G., *J. Ultrastructure Res.*, **3**, 216 (1959).
[14] Crick, F. H. C., Griffith, J. S., and Orgel, L. E., *Proc. U.S. Nat. Acad. Sci.*, **43**, 416 (1957).
[15] McQuillen, K., Roberts, R. B., and Britten, R. J., *Proc. U.S. Nat. Acad. Sci.*, **45**, 1437 (1959).
[16] Schachtschabel, D., and Zillig, W., *Z. physiol. Chem.*, **314**, 262 (1959).
[17] McCorquodale, D. J., and Zillig, W., *Z. physiol. Chem.*, **315**, 86 (1959).

## An Iron Requirement for a Dissimilatory Nitrate Reductase in *Neurospora crassa*

Nitrate reduction in *Neurospora* is usually considered to be an assimilatory process. Nitrate reductase is a flavoprotein containing molybdenum, and the sequence of electron transfer has been determined as follows:

$$\text{TPNH} \rightarrow \text{FAD} \rightarrow \text{Mo} \rightarrow \text{NO}_3^- \qquad \text{(ref. 1)}$$

where TPNH is reduced triphosphopyridine nucleotide and FAD is flavin-adenine-dinucleotide. It was shown that a deficiency of iron in the felts grown under aerobic conditions did not depress enzyme activity[2,3]. In this communication we report that *Neurospora* grown at low oxygen tensions dissimilates nitrate, and under these conditions nitrate reductase is dependent on iron as well as molybdenum for maximum activity.

*Neurospora crassa*, wild-type 5297*a*, was grown in a modified Fries medium[2] with sodium nitrate as the sole source of nitrogen. The following methods[4] were used to remove trace metals from the macronutrients of the culture medium: phosphate co-precipitation for iron, manganese and zinc and acid copper-sulphide co-precipitation for copper and molybdenum. The fungus was grown at 25° C., in the dark, for the prescribed period and harvested in a small Büchner funnel. The felts were well washed with 2 per cent (w/v) glucose, squeezed dry and stored at − 17° C. They were ground in a cold pestle and mortar with seven times their weight of cold 0·1 *M* phosphate

(*p*H 7·4) and homogenized further in a Ten Broeck glass macerater.

The enzyme was assayed as follows: 0·1–0·2 ml. homogenate, 0·1 ml. $10^{-1}$ *M* sodium nitrate, 0·1 ml. $2 \times 10^{-3}$ *M* reduced triphosphopyridine nucleotide and 0·5 ml. $10^{-1}$ *M* phosphate (*p*H 7·4). The mixture was incubated for 10 min. at 30° C. and then 0·1 ml. $6 \times 10^{-3}$ *M* *p*-benzoquinone and 2 mgm. *p*-benzoquinone reductase[5] added to oxidize residual reduced triphosphopyridine nucleotide. After 4 min. 0·1 ml. *M* zinc acetate and 3 ml. 98 per cent (v/v) ethanol were added and the precipitate centrifuged at 1,000*g* for 5 min. Nitrite was determined in an aliquot of the clear supernatant solution by adding sulphanilamide and α-naphthylethylenediamine[6]. In the control tubes, reduced triphosphopyridine nucleotide was omitted. Cytochromes *b* and *c* were viewed in a Zeiss hand spectroscope and protein determined by the Folin method[8].

Two distinct stages can be distinguished during the growth of *Neurospora* in still culture. During the first stage, 2–3 days after inoculation, the felts were submerged and growing under semi-anaerobic conditions, when nitrate was dissimilated rapidly and nitrite accumulated in the felts and in the culture medium. After 3–4 days growth, however, the felts broke the surface of the culture solution and entered a more aerobic environment, and nitrite which was produced earlier was now re-utilized. The results in Table 1 show that deficiencies of either iron or molybdenum in felts at the 2-day stage reduced enzyme activity, but after 5 days growth molybdenum deficiency only depressed nitrate reductase. The results in Fig. 1 confirm the iron requirement for nitrate reduction during early growth, when the felts were submerged, since enzyme activity of the felts increased from deficiency to sufficiency levels of iron in the culture medium. The enzyme activity of 5-day felts, however, was independent of the iron status, thus confirming previous work[3,9]. Deficiencies of either copper, manganese or zinc did not decrease enzyme activity at any stage of growth.

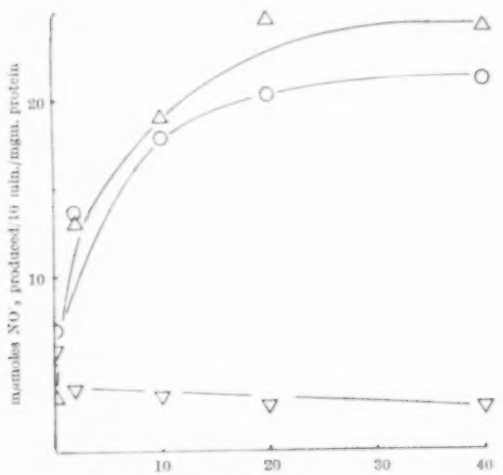



Fig. 1. Effect of the iron content of the culture medium on nitrate reductase activity in homogenates of *Neurospora crassa* harvested after 2, 3 and 5 days. *Neurospora* was grown at 25° C. in still culture depleted of iron to which 2, 10, 20 or 40 μgm./iron/200 ml. was returned. △, Felts harvested after 2 days growth; ○, felts harvested after 3 days growth; ▽, felts harvested after 5 days growth

Table 1. Effect of Deficiencies of either Copper, Iron, Molybdenum, Manganese or Zinc on the Growth of *Neurospora crassa* and on Nitrate Reductase Activity

| Time of harvest (days) | Nitrate reductase and yield of the felts | Normal felts (per cent) | | | | |
|---|---|---|---|---|---|---|
| | | Omit copper | Omit iron | Omit manganese | Omit molybdenum | Omit zinc |
| 2 | Enzyme | 100 | 21 | 98 | 61 | 103 |
| | Yield | 83 | 78 | 90 | 93 | 61 |
| 5 | Enzyme | 120 | 109 | 102 | 43 | 110 |
| | Yield | 49 | 9 | 67 | 52 | 8 |

Culture media were purified by the techniques described in the text and all the essential trace elements returned except the one to be studied. Felts were harvested after either 2 or 5 days growth in still culture at 25° C.

The effect of oxygen tension in the medium on nitrate reductase in the felts is shown in Table 2. At low oxygen tension the enzyme activity was markedly increased, nitrite accumulated and cytochromes *b* and *c* increased in the felts. The results suggest that, when oxygen is limiting, nitrate is dissimilated by an active nitrate reductase. This enzyme requires both iron and molybdenum for its activity, and in this respect it is similar to that prepared from the denitrifying bacterium, *Pseudomonas aeruginosa*[7]. During denitrification in bacteria and dissimilation of nitrate in *Escherichia coli*, the cytochrome contents of the cells increase and it is probable that they function during nitrate reduction[7,8]. A fuller account of this work is in preparation.

Table 2. Effect of Oxygen Tension in the Culture Medium on the Yield, Nitrate Reductase Activity, Nitrite and Cytochrome Contents of the Felts of *Neurospora crassa*

| $O_2$ in $N_2$ (per cent) | Yield (gm. fresh weight) | Nitrate reductase (mμmoles $NO_3^-$ 10 min./ mgm. protein) | Nitrite (mμmoles $NO_2^-$/ mgm. protein) | Cytochromes *b* + *c* (relative values) |
|---|---|---|---|---|
| 1 | 6·8 | 60·5 | 159 | 4 |
| 5 | 7·9 | 8·7 | 24 | 2 |
| 10* | 9·6 | 2·3 | 9 | 1 |
| 21 | 16·8 | 1·3 | 0 | 1 |

*Neurospora* was grown in 500 ml. culture medium dispensed in 1½ litre Erlenmeyer flasks. The flasks were shaken on a reciprocating shaker (100 oscillations/min.) at 25° C. and various gas mixtures of oxygen in nitrogen dispersed in the medium through a No. 2 porosity glass sinter. Felts were harvested after 3 days.

We are grateful to Dr. H. E. Davenport for determining cytochromes in the fungus. One of us (G. C. W.) is indebted to the Ministry of Agriculture, Food and Fisheries for a postgraduate studentship award.

G. C. Walker
D. J. D. Nicholas*

Chemical Microbiology Department,
Long Ashton Research Station,
University of Bristol.

* Member of the Scientific Staff of the Agricultural Research Council seconded to the University of Bristol.

[1] Nicholas, D. J. D., and Nason, A., *J. Biol. Chem.*, **211**, 183 (1954).
[2] Nicholas, D. J. D., Nason, A., and McElroy, W. D., *J. Biol. Chem.*, **207**, 341 (1954).
[3] Nicholas, D. J. D., *J. Sci. Food Agric.*, **8**, 515 (1957).
[4] Nicholas, D. J. D., and Fielding, A. H., *J. Hort. Sci.*, **26**, 125 (1951).
[5] Wosilait, W. D., and Nason, A., *J. Biol. Chem.*, **206**, 255 (1954).
[6] Lowry, O. H., Rosenbrough, W. J., Farr, A. L., and Randall, R. J., *J. Biol. Chem.*, **193**, 265 (1951).
[7] Fewson, C. A., and Nicholas, D. J. D., *Biochem. J.*, **77**, 3 (1960).
[8] Verhoeven, W., and Takeda, Y., in "Inorganic Nitrogen Metabolism", edit. by McElroy and Glass, 159 (Johns Hopkins Univ. Press, Baltimore, 1956).
[9] Sato, R., in "Inorganic Nitrogen Metabolism", edit. by McElroy and Glass, 163 (Johns Hopkins Univ. Press, Baltimore, 1956.)

## Synthesis of L-Methionyl-L-Glutamyl-L-Histidyl-L-Phenylalanyl-L-Arginyl-L-Tryptophyl-Glycine and its Melanocyte-stimulating and Corticotropin-releasing Activity

THE occurrence of the heptapeptide, L-methionyl-L-glutamyl-L-histidyl-L-phenylalanyl-L-arginyl-L-tryptophyl-glycine, in both adrenocorticotropins (ACTH) and melanotropins (MSH)[1-3] has led to synthesis of various peptides[4-7] related to all or part of this amino-acid sequence. In recent reports[8] the synthesis of the glutamine analogue of this heptapeptide has been described, and it was shown to possess corticotropin-releasing (CRF) activity. In the course of the synthesis of a nonadecapeptide[9] which has a sequence identical with the first 19 amino-acid residues of ACTH and which possesses ACTH and MSH activity, we have synthesized the heptapeptide in its natural form and found it to have both MSH and CRF activity.

Carbobenzoxy-$N^G$-tosyl-L-arginyl-L-tryptophyl glycine methyl ester[7] was decarbobenzoxylated by catalytic hydrogenation and the product was coupled with carbobenzoxy-Im-benzyl-L-histidyl-L-phenylalanine[6] by the *p*-nitrophenyl ester method[10]. The resulting protected pentapeptide (I) was obtained in the form of crystalline white powder from acetone–methanol solution: m.p. 144–146° C., with sintering from 142° C.; $[\alpha]_D^{25}$, − 22·5° (*c*. 2, in methanol); $[\alpha]_D^{25}$, − 25° (*c*. 1, in acetone). Analysis for $C_{52}H_{63}N_{11}O_{10}S$: Calc.: C, 62·56; H, 5·81; N, 14·08. Found: C, 62·36; H, 5·61; N, 14·16.

Peptide I was catalytically hydrogenated and the product was allowed to react with the *p*-nitrophenyl ester of carbobenzoxy-L-methionyl-γ-methyl-L-glutamic acid. The latter (peptide II) was prepared by condensation of γ-methyl-L-glutamic acid[11] with carbobenzoxy-L-methionine by means of the *p*-nitrophenyl ester method[10]. Peptide II obtained in this manner was recrystallized from 75 per cent aqueous ethanol: m.p. 134–135° C.; $[\alpha]_D^{24}$, − 17° (*c*. 2, methanol). Analysis for $C_{15}H_{26}N_2O_5S$: Calc.: C, 53·50; H, 6·15; N, 6·57. Found: C, 53·64; H, 6·16; N, 6·86.

The crystalline protected heptapeptide di-ester [m.p. 180–182° C.; $[\alpha]_D^{25°}$, − 39° (*c*. 1, 98 per cent acetone). Analysis for $C_{65}H_{81}N_{13}O_{14}S_2$: Calc.: C, 59·67; H, 5·97; N, 12·31. Found: C, 59·44; H, 6·13; N, 13·04] was saponified and then treated with sodium in liquid ammonia[13] to remove the protecting groups. The crude heptapeptide was purified by counter-current distribution in the 2-butanol–0·5 per cent trichloracetic acid system: the material with a distribution coefficient of 0·60 was isolated and shown to be the desired heptapeptide. When acid hydrolysates of the product (tryptophan was destroyed by the acid hydrolysis) were analysed for amino-acid content by the procedure of Spackman, Stein and Moore[14], the following results were obtained: $Met_{0.9}Glu_{0.9}His_{0.7}Phe_{1.0}Arg_{1.0}Gly_{1.1}$. Digestion of the synthetic heptapeptide with leucine aminopeptidase[15] gave rise to the expected constituent amino-acids as determined by quantitative analysis[16]: $Met_{0.9}Glu_{0.9}His_{0.9}Phe_{1.0}Arg_{1.0}Try_{1.0}Gly_{1.0}$.

On the basis of the frog skin assay procedure[17], the heptapeptide possesses an MSH potency of $1{\cdot}4 \times 10^8$ units per gm.; a single dose of 0·0005 mgm. caused a change in melanophore index from 1+ to 3+ within 1 hr. in hypophysectomized *Rana pipiens*, as determined by the *in vivo* assay method of Hogben and Slome[18]. When 0·1 mgm. of the synthetic product was assayed by the *in vitro* adrenal method[19], it did not exhibit ACTH activity, but 0·001 mgm. was found to cause the release of ACTH from the rat anterior pituitary, in accordance with the results of the *in vitro* procedure of Saffran and Schally[20].

It is of interest that the MSH potency of the heptapeptide is considerably higher than that reported for the glutamine analogue[8]. The question of whether or not differences in corticotropin-releasing activity exist between the heptapeptide and its glutamine analogue cannot be answered satisfactorily at the present time, since there are no standard preparations or standardized assay procedures for comparing corticotropin-releasing substances.

This work was supported in part by a grant (*RG*-2907) from the United States Public Health Service of the National Institutes of Health, and a grant from the Albert D. and Mary Lasker Foundation, New York.

CHOH HAO LI
EUGEN SCHNABEL*
DAVID CHUNG
TUNG-BIN LO†

Hormone Research Laboratory,
University of California,
Berkeley 4, California.

* Fulbright grantee 1958–60, on leave of absence from Deutsches Wollforschungsinstitut Veltraanplatz, Aachen, Germany.

† On leave of absence from National Taiwan University, Formosa.

[1] Li, C. H., "Adv. Prot. Chem.", **12**, 269 (1957).
[2] Li, C. H., *Lab. Invest.*, **8**, 574 (1959).
[3] Harris, J. I., *Brit. Med. Bull.*, **16**, 189 (1960).
[4] Hofmann, K., Woolner, M. E., Spühler, G., and Schwartz, E. T., *J. Amer. Chem. Soc.*, **80**, 1486 (1958). Hofmann, K., Thompson, T. A., Woolner, M. E., Spühler, G., Yajima, H., Cipera, J. D. and Schwartz, E. T., *ibid.*, **82**, 3721 (1960).
[5] Schwyzer, R., and Li, C. H., *Nature*, **182**, 1069 (1958).
[6] Li, C. H., Schnabel, E., and Chung, D., *J. Amer. Chem. Soc.*, **82**, 2062 (1960).
[7] Schnabel, E., and Li, C. H., *J. Amer. Chem. Soc.*, **82**, 4576 (1960).
[8] Kappeler, H., and Schwyzer, R., *Experientia*, **16**, 415 (1960). Privat de Garilhe, M., Gros, C., Porath, J., and Lindner, E. V., *Experientia*, **16**, 414 (1960).
[9] Li, C. H., Meienhofer, J., Schnabel, E., Chung, D., Lo, T., and Ramachandran, J., *J. Amer. Chem. Soc.*, **82**, 5760 (1960).
[10] Bodanszky, M., *Nature*, **175**, 685 (1955).
[11] Hanby, W. E., Waley, S. G., and Watson, J., *J. Chem. Soc.*, 3239 (1950).
[12] Hofmann, K., Jöhl, A., Furlenmeier, A. E., and Kappeler, H., *J. Amer. Chem. Soc.*, **79**, 1636 (1957).
[13] du Vigneaud, V., and Behrens, O. K., *J. Biol. Chem.*, **177**, 27 (1937).
[14] Spackman, D. H., Stein, W. H., and Moore, S., *Anal. Chem.*, **30**, 1190 (1958).
[15] Smith, E. L., and Spackman, D. H., *J. Biol. Chem.*, **212**, 271 (1955).
[16] Levy, A. L., *Nature*, **174**, 126 (1954).
[17] Shizume, K., Lerner, A. B., and Fitzpatrick, T. B., *Endocrinol.*, **54**, 533 (1954).
[18] Hogben, L. T., and Slome, D., *Proc. Roy. Soc.*, B, **108**, 10 (1931).
[19] Saffran, M., and Schally, A. V., *Endocrinol.*, **56**, 523 (1955).
[20] Saffran, M., and Schally, A. V., *Canad. J. Biochem. Physiol.*, **33**, 408 (1955).

## Biosynthesis of $^{14}$C-Sclareol and β-Sitosterol from 2-$^{14}$C-Mevalonic Acid

*Salvia sclarea*, a member of the family Labiatae, contains the bicyclic diterpene sclareol[1] and at least two acidic pentacyclic triterpenes[2]. From the non-saponifiable fraction, β-sitosterol has recently been isolated[3]; the plant thus provides a means of studying simultaneously the biosynthesis of diterpene, sterol and pentacyclic triterpene.

Several flowering sections of *S. sclarea* were cut 10–15 cm. above the root and the cut ends were immersed in an aqueous solution of 2-$^{14}$C-sodium mevalonate. (The 2-$^{14}$C-mevalonic acid was purchased from Isotopes Specialties, Inc., Burbank, California, and had a specific activity of 0·66 mc./m*M*. All carbon-14 determinations were carried out with a windowless gas-flow counter on infinitely thin samples plated and dried on nickel planchets 2·5 cm. in diameter.) A total of 60 μc. was absorbed. After standing over-night with continuous absorption of distilled water provided, the sections were divided into the various parts indicated in Table 1 and allowed to dry in air for one week. Each part (respectively) was exhaustively extracted with hot 95 per cent ethanol, which was afterwards distilled almost to dryness *in vacuo*. The residue was steam-distilled and the portion left, after drying *in vacuo*, was extracted with hot ligroin (boiling point 90–100°). The latter was washed with 1 per cent potassium hydroxide and water, then distilled to dryness. The residue contained sclareol and β-sitosterol. These were separated on active alumina, the sterol being removed with benzene, and the diterpene afterwards being removed with 2 per cent ethanol in benzene. From the benzene residue after distillation, sterol was precipitated by Sperry and Webb's method[6]. The crude sclareol fraction was sublimed twice at 10–30μ mercury pressure, at which stage sclareol melting at 99–102° was obtained. Table 1 shows the yield and carbon-14 content of sclareol and sterol expressed on a common weight basis, at what was considered a comparable stage of purification.

Table 1. Incorporation of 2-$^{14}$C-Mevalonic Acid into Sclareol and β-Sitosterol of *Salvia sclarea*

| Plant part | Sclareol Yield (mgm./gm. dried plant) | Sclareol Carbon-14 (c./m./gm. dried plant) | Sterol Yield (mgm./gm. dried plant) | Sterol Carbon-14 (c./m./gm. dried plant) |
|---|---|---|---|---|
| Flowers | 39·19 | 23,196 | 3·09 | 124,520 |
| Flower stems | 26·81 | 22,735 | 1·21 | 187,421 |
| Leaves | 2·75 | 7,276 | 1·36 | 11,238 |
| Main stem | 4·18 | 5,938 | 0·58 | 34,341 |
| Stipules | 23·81 | 35,198 | 1·45 | 96,493 |

On several additional sublimations and recrystallizations from aqueous methanol and ligroin, the specific activity of the sclareol (melting point 104–106°) continued to drop. On five-fold dilution with non-radioactive sclareol, hydrogenation under pressure in the presence of platinum catalyst, and two recrystallizations of the product from ligroin, dihydrosclareol (melting point 114–116°) with the following specific activities was obtained: flowers, 14 c./m. per mgm., flower stems, 9 c./m. per mgm., leaves, 12 c./m. per mgm., main stem, 7 c./m. per mgm., stipules, 14 c./m. per mgm. These figures indicate a very low order of incorporation of carbon-14 from mevalonic acid into the sclareol molecule. The sterol fractions, on the other hand, retained their high specific activity on an additional precipitation with digitonin. It is tempting to assume that, under these experimental conditions, the mevalonic acid was preferentially incorporated into the sterol molecule rather than into the diterpene. However, it is equally plausible that the turnover of the sclareol molecule may exceed that of the sterol, and other interpretations may become necessary as our information on the biosynthesis of terpenoids in higher plants is expanded. Efforts are in progress to determine in more detail the extent of incorporation of carbon-14 into the sterol (β-sitosterol) and acidic triterpene fractions.

This investigation was supported by a research grant from the National Institutes of Health, U.S. Public Health Service.

Harold J. Nicholas
University of Kansas Medical Center,
Kansas City 12, Kansas.

[1] Volmar, Y., and Jermstad, A., *C.R. Acad. Sci., Paris*, **186**, 783 (1928).
[2] Nicholas, H. J., *J. Amer. Pharm. Assoc.*, Scientific ed., **47**, 731 (1958).
[3] Nicholas, H. J., *J. Amer. Pharm. Assoc.*, Scientific ed. (in the press).
[4] Sperry, W. M., and Webb, M., *J. Biol. Chem.*, **187**, 97 (1950).

## Utilization of the Stereoisomers of *Iso*leucine by *Lactobacillus arabinosus* 17–5

It has been reported by several authors[1–3] that *Lactobacillus arabinosus* is capable of utilizing L-allo*iso*leucine as well as L-*iso*leucine in the presence of vitamin $B_6$ but unable to utilize D-allo*iso*leucine; there has been only one report[4] that D-*iso*leucine was partially utilizable.

We have studied the utilization of the four stereoisomers of *iso*leucine by lactic acid bacteria such as *Streptococcus faecalis R*, *Leuconostoc mesenteroides P-60* and *Lactobacillus arabinosus* 17–5, which are widely used for the microbioassay of amino-acids. As a result, in contrast with the previous reports, *Lact. arabinosus* was found to be able to utilize all four stereoisomers of *iso*leucine in the presence of vitamin $B_6$, but not in its absence.

The medium used in the present experiment was essentially the same as described by Henderson and Snell[5], except that 0·6γ of pyridoxamine, 0·6γ of pyridoxal and 2γ of pyridoxine per 2 ml. of culture medium were used as vitamin $B_6$ compounds and L-isomers of amino-acids were used except for alanine, phenylalanine and serine. Incubation was carried out at 37° in test-tubes which were read at suitable intervals with a spectrophotometer at 660 mμ.

The growth-responses of the three micro-organisms to the *iso*leucine isomers in the presence or absence of vitamin $B_6$ are summarized in Table 1.

Table 1. Growth Response of Lactic Acid Bacteria to *iso*Leucine Isomers

| *iso*Leucine isomers | *Lact. arabinosus* $B_6(+)$ | *Lact. arabinosus* $B_6(-)$ | *Str. faecalis* $B_6(+)$ | *Str. faecalis* $B_6(-)$ | *Leuc. mesenteroides* $B_6(+)$ | *Leuc. mesenteroides* $B_6(-)$ |
|---|---|---|---|---|---|---|
| L-*iso*Leucine | + | + | + | + | + | + |
| L-Alloisoleucine | + | – | – | – | – | – |
| D-*iso*Leucine | + | – | – | – | – | – |
| D-Alloiso-leucine | + | ± | – | – | – | – |

The concentration of isoleucine isomers was 2 ~ 100γ per 2 ml. tube. Incubation was carried out for 96 hr.

It is of interest that D-*iso*leucine and D-allo*iso*leucine were also utilized in the presence of vitamin $B_6$ by *Lact. arabinosus*. This utilization of *iso*leucine isomers by *Lact. arabinosus* was further studied in detail. Approximately the same final level of growth was attained with L-allo*iso*leucine, D-*iso*leucine and D-allo*iso*leucine as that with L-*iso*leucine at higher concentrations (Fig. 1,*A*). However, it was observed that maximum growth with L-allo*iso*leucine and D-allo*iso*leucine was attained respectively in about 24 hr. and 48 hr. longer than the time required with L-*iso*leucine. Response to D-*iso*leucine was lowest among the stereoisomers tested, and maximum growth

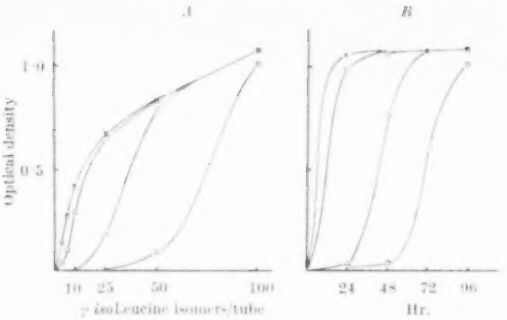



Fig. 1. Growth responses of *Lact. arabinosus* to *iso*leucine isomers. Incubation was carried out in the medium of initial *p*H 6·0. *A*, contained 100γ stereoisomers per tube; *B*, incubated for 96 hr. ×, L-*iso*leucine; ○, L-allo*iso*leucine; □, D-*iso*leucine; △, D-allo*iso*leucine

was reached 72 hr. later than with L-*iso*leucine (Fig. 1,*B*).

The adjustment of the initial *p*H of the medium to 6·0 or 5·3 resulted in more rapid growth with the stereoisomers than that of *p*H 6·8, as previously noted by Meister[3] in the case of L-*iso*leucine and L-allo*iso*leucine. Employment of the medium reported by Steele *et al.*[4] and the medium of Henderson and Snell[5] using mainly the DL-forms of amino-acids with modified vitamin supplement, which conformed with that of the former, resulted in slower growth response with D-*iso*leucine and D-allo*iso*leucine than that of the medium employed by us, which contained mainly L-form of amino-acids. Further work on the influence of the components of the medium revealed that the presence of excessive amounts of valine and leucine, especially the latter, inhibited the utilization of *iso*leucine isomers. This difference of the components of the media seems to account for the discrepancy between the reports on the utilization of *iso*leucine isomers. Of the vitamin $B_6$ compounds, pyridoxamine was most effective for the utilization of *iso*leucine isomers and pyridoxal followed. Activity of pyridoxine was lowest and was only effective for the utilization of L-allo*iso*leucine under the conditions employed by us.

We also found that the strain cultured successively in the medium containing one of the other *iso*leucine isomers in place of L-*iso*leucine was able to utilize *iso*leucine isomers more rapidly than the ordinary strain cultured in the medium containing L-*iso*leucine. For example, growth responses of the strain cultured five times in succession in the medium containing D-*iso*leucine and of ordinary strain are shown in Fig. 2.

Compared with the ordinary strain, the strain adapted to D-*iso*leucine medium showed marked acceleration in response not only specifically to D-*iso*leucine but also to L-allo*iso*leucine and D-allo*iso*leucine. By employing these findings, it is possible to determine microbiologically the total amounts of synthetic *iso*leucine and allo*iso*leucine in mixtures.

Ichiro Chibata
Shigeki Yamada
Hiroshi Ito

Osaka Research Laboratory,
Tanabe Seiyaku Co., Ltd.,
Kashima-cho, Higashiyodogawa-ku,
Osaka, Japan.

[1] Hegsted, D. M., *J. Biol. Chem.*, **157**, 741 (1945).
[2] Hood, D. W., and Lyman, C. M., *J. Biol. Chem.*, **186**, 195 (1950).
[3] Meister, A., *J. Biol. Chem.*, **195**, 813 (1951).
[4] Koser, S. A., and Thomas, J. L., *J. Bacteriol.*, **73**, 477 (1957).
[5] Henderson, L. M., and Snell, E. E., *J. Biol. Chem.*, **172**, 15 (1948).
[6] Steele, B. F., Sauberlich, H. E., Reynolds, M. S., and Baumann, C. A., *J. Biol. Chem.*, **177**, 533 (1948).

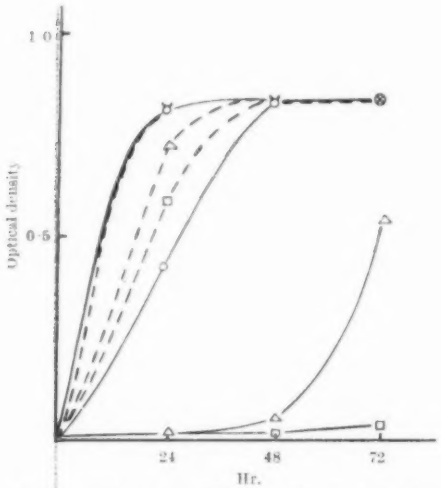



Fig. 2. Growth responses of *Lact. arabinosus* adapted for D-*iso*leucine medium and of ordinary strain to 50γ *iso*leucine isomers. ×, L-*iso*leucine; ○, L-allo*iso*leucine; □, D-*iso*leucine; △, D-allo*iso*leucine. ——, Ordinary strain; – – –, adapted strain

## A Simple Paper Chromatographic Method for Determination of Amino-Acid Activation Profiles in Tissue Preparations

The capacity of an enzyme preparation to activate amino-acids is usually measured by means of the amino-acid dependent isotope exchange reaction between pyrophosphate labelled with phosphorus-32 and adenosine triphosphate[1]. According to the procedure usually adopted, the labelled adenosine triphosphate is separated from the other components of the incubation mixture by treatment with charcoal. The pyrophosphate of the adsorbed adenosine triphosphate is eluted by hydrolysis with hot hydrochloric acid. The radioactivity is determined and calculated per μmole adenosine triphosphate. For measurement of whole series of individual amino-acid activating enzyme activities in tissue preparations there was a need of a simple procedure which also could be used on a semi-micro scale. A scanning method was therefore developed involving paper chromatography combined with radioautography of the papergrams.

The incubation mixture contained, in a final volume of 0·25 ml.: adenosine triphosphate–magnesium chloride (1·2 μmoles), pyrophosphate labelled with phosphorus-32 (0·8 μmole), potassium fluoride (12 μmoles), *tris*(hydroxymethyl)aminomethane buffer, *p*H 7·8 (30 μmoles), and the enzyme preparation (0·13 ml.). Each tube also contained 0·6 μmole of the L-amino-acid to be tested. Usually, 18 separate amino-acids were assayed. The period of incubation (35° C.) varied with the activity of the enzyme preparation from 10 to 60 min. After the incubation,

0·05 ml. of the chromatography solvent (see below) was added, giving the solution a total volume of 0·30 ml. The tubes were centrifuged, and 10 µl. of the clear supernatant was applied to Whatman No. 1 chromatographic paper. The papergrams were developed in *iso*butyric acid/ammonia/water (50 : 1 : 20) for 72 hr. at 18° C. by the descending technique. The labelled adenosine triphosphate was localized by radioautography (Gevaert, X-ray film), as well as the inorganic phosphate, which was present in the labelled pyrophosphate solution used, and which to some extent was formed during incubation. Adenosine triphosphate also was outlined by use of a 'Mineralight' lamp. For quantitative determination of specific activity, radioactivity of adenosine triphosphate was measured by a thin mica window counter (Tracerlab) on a 2·4-cm. diameter circle cut from the centre of the adenosine triphosphate spot. The radioactivity of 10 µl. of the labelled pyrophosphate solution used in the experiment, but at a concentration of 0·8 µmole in 0·30 ml., was measured in the same way. The percentage exchange values were calculated by the method of Davie *et al.*[2].

A typical radioautograph is illustrated in Fig. 1. The experiment was performed with the *p*H 5 enzyme fraction of rat liver. It is obvious from the radioautograph that the intensity of the adenosine triphosphate spots already gave a fairly good indication of the activity of activating enzymes for the different amino-acids. The general information obtained in this way may be supplemented by a more exact determination of the percentage exchange values as is shown in Table 1 using purified ribonucleoprotein particles from rat liver[3,4] and $S_{50}$-protein. $S_{50}$-protein is an enzyme preparation obtained from the *p*H-5 soluble fraction of rat liver by fractionation with ethanol and ammonium sulphate[3,5]. As is shown in Table 1, there was a slight but significant stimulation of the isotope exchange between labelled pyrophosphate and adenosine triphosphate by most

Table 1. Activation of Amino-Acids by Enzyme Preparations of Rat Liver, measured by Isotope Exchange between Pyrophosphate labelled with Phosphorus-32 and Adenosine Triphosphate

| Amino-acid | Percentage exchange per mgm. protein | |
|---|---|---|
| | Purified ribonucleoprotein particles | $S_{50}$-protein |
| Alanine | 0·4 | 1·3 |
| Arginine | 0·1 | 0·1 |
| Aspartic acid | 1·1 | 1·7 |
| Cysteine | 0·2 | 7·2 |
| Glutamic acid | 0·9 | 0·0 |
| Glycine | 0·5 | 1·2 |
| Histidine | 0·6 | 3·3 |
| *iso*Leucine | 0·6 | 1·4 |
| Leucine | 2·3 | 0·6 |
| Lysine | 0·9 | 0·4 |
| Methionine | 0·5 | 1·5 |
| Phenylalanine | 0·1 | 1·2 |
| Proline | 0·0 | 9·0 |
| Serine | 0·4 | 3·0 |
| Threonine | 0·1 | 3·3 |
| Tryptophan | 0·6 | 0·8 |
| Tyrosine | 0·8 | 6·0 |
| Valine | 0·2 | 1·7 |

Incubation system: adenosine triphosphate–magnesium chloride (1·2 µmoles), labelled pyrophosphate (0·8 µmole), potassium fluoride (12 µmoles), *tris*(hydroxymethyl)aminomethane buffer, *p*H 7·8 (30 µmoles), and about 2 mgm. of the enzyme protein. Each tube contained, in addition, 0·6 µmole of the L-amino-acid indicated. Final volume: 0·25 ml. Incubation for 60 min. at 35° C.

Ribonucleoprotein particles of rat liver were prepared by the method of Rendi and Hultin (ref. 3) and purified (ref. 4). Before being added to the incubation tubes they were resuspended in a medium of 0·25 *M* sucrose, 0·035 *M* *tris*(hydroxymethyl)aminomethane buffer, *p*H 7·8, 0·025 *M* potassium chloride and 0·01 *M* magnesium chloride. $S_{50}$-protein was a purified preparation of the *S*-protein of Sachs (ref. 5) obtained from the *p*H-5 soluble rat liver fraction (ref. 3).

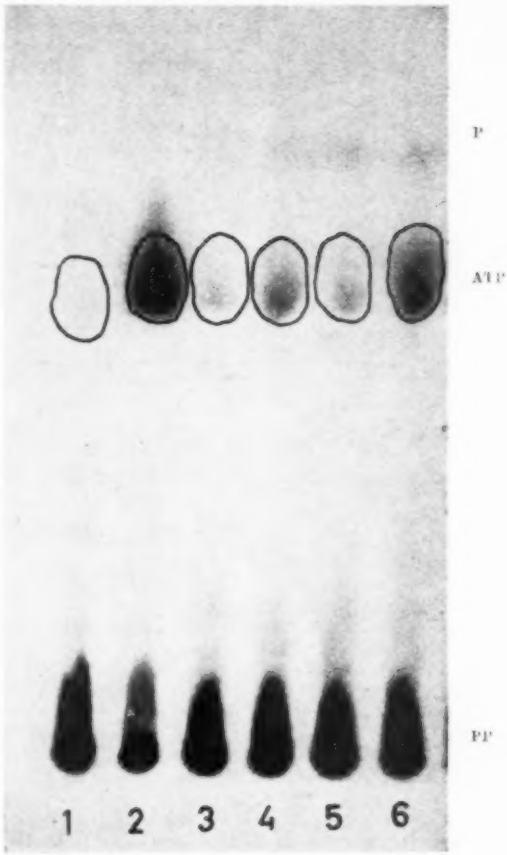



Fig. 1. Radioautograph, illustrating activation of amino-acids by the *p*H-5 enzyme fraction (ref. 2) of rat liver (0·8 mgm. protein), measured as isotope exchange between pyrophosphate-$^{32}$P (PP) and adenosine triphosphate (ATP). Incubation for 30 min. at 35° C. Incubation system as in Table 1. Separation of adenosine triphosphate, pyrophosphate-$^{32}$P and phosphate on Whatman No. 1 paper. Development for 72 hr. at 18° C., descending. Encircled areas indicate ultra-violet absorption. Samples of incubation mixtures applied on base-line contained: 1, no amino-acids; 2, amino-acid mixture of 12 amino-acids (ref. 1); 3, histidine; 4, alanine; 5, serine; 6, threonine

of the amino-acids in the system with purified ribonucleoprotein particles. As has been shown previously[5], the capacity of amino-acid activation was rather low in the $S_{50}$-protein preparation, except in the cases of L-proline, L-cysteine and L-tyrosine.

I wish to thank Dr. T. Hultin for his helpful advice and criticism, and Mrs. G. Beskow for technical assistance. The work was supported by a grant from the Swedish Cancer Society.

Alexandra von der Decken

Wenner-Gren Institute for Experimental Biology, University of Stockholm.

[1] Hoagland, M. B., Keller, E. B., and Zamecnik, P. C., *J. Biol. Chem.*, **218**, 345 (1956).
[2] Davie, E. V., Koningsberger, V. V., and Lipmann, F., *Arch. Biophys.*, **65**, 21 (1956).
[3] Rendi, R., and Hultin, T., *Exp. Cell Res.*, **19**, 253 (1960).
[4] Decken, A. von der, and Hultin, T., *Biochim. Biophys. Acta*, **40**, 189 (1960).
[5] Sachs, H., *J. Biol. Chem.*, **228**, 23 (1958).
[6] Decken, A. von der, and Hultin, T., *Biochim. Biophys. Acta*, **45**, 139 (1960).

## PHYSIOLOGY

### Anticomplementary Action of Aspirin

THE role of complement ($C'$) in allergy[1,2], anaphylaxis[3,4], and the possible role of antigen–antibody reactions, and thus also of $C'$[5] in rheumatism and general fever phenomena, induced us to determine whether classical antidotes against these diseases, like aspirin (acetyl-salicylic acid)[6], salicylic acid, quinine and cortisone, have any anticomplementary action.

For this purpose the influence was studied of solutions of these agents on the hæmolysis normally provoked by the action of guinea pig's serum ($C'$) on sheep erythrocytes ($E$) sensitized with rabbit anti-sheep erythrocytes serum ($A$): $EAC'$–$E^*$. Standard hæmolysis tubes were filled with 0·5 ml. $C'$, diluted 1/100; 0·1 ml. $E$, diluted 1/50, and 0·1 ml. $A$, diluted 1/100, and incubated at 37° C. during 30 min. With the standard $C'$, $A$ and $E$ reagents obtained from the Pasteur Institute, Paris, complete hæmolysis was always obtained in these circumstances. The dilutions were made in Michaelis's barbital buffer, $p$H = 7·4, $\mu$ = 0·15, containing $1{\cdot}5 \times 10^{-4}$ $M$ $Ca^{++}$ and $5 \times 10^{-4}$ $M$ $Mg^{++}$. The different dilutions of aspirin, etc., tested were also made in this buffer, and the solutions thus obtained then served to dilute the $C'$. In this way the total volume of the reagents was kept constant, and the material to be tested for its action on $C'$ was brought into contact with $C'$ before any other reagent. The results are presented in Table 1.

Table 1. THE ANTICOMPLEMENTARY EFFECT OF ASPIRIN, SALICYLATE, QUININE AND CORTISONE

| | Concentration (weight/volume) giving 50 per cent hæmolysis in 30 min. | Smallest concentration completely inhibiting hæmolysis in 30 min. |
|---|---|---|
| Aspirin | $4 \times 10^{-4}$ | $5 \times 10^{-4}$ |
| Sodium salicylate | no inhibition | |
| Quinine | $> 5 \times 10^{-4}$ slight delay of hæmolysis | |
| Cortisone acetate | $2{\cdot}5 \times 10^{-4}$ | $3{\cdot}3 \times 10^{-4}$ |

It is clear from Table 1 that aspirin is the only compound tested which has a strong anticomplementary action within the normal therapeutical doses, at least so far as guinea pig serum is concerned (which contains more $C'$ than human serum). Sodium salicylate seems to have no action at all, which seems strange, as it is still much in use in many countries, instead of aspirin. Its beneficent action (if any[7]) may perhaps be explained by an acetylation during its metabolism. Quinine, which has only a slightly retarding action on $C'$ hæmolysis, probably owes its beneficent action to a different mechanism altogether. Cortisone acetate is only anticomplementary in rather stronger than therapeutical doses: the mechanism of its action must be complex.

We have also determined which of the $C'$ factors is inhibited by aspirin. We suspected that the inhibited factor is $C_3'$, because of the work of Osler *et al.*[3], and we were supported in this suspicion when $EA$ + ($C'$ + aspirin), after centrifuging three times and washing with buffer (to remove the aspirin), gave rise to hæmolysis when fresh $C'$ + ethylenediamine disodium acetate (EDTA) was added[8]. This hypothesis was confirmed by using $C_4'$ (prepared by heating the serum at 56° C. for 20 min. and then treating it with ammonium[9]), instead of $C'$ + EDTA, because this $C_3'$ also caused the [$EA$ + ($C'$ + aspirin)], washed three times, to hæmolyse.

We have not up to now determined whether the inhibition of $C_3'$ by aspirin is irreversible or reversible[10]. We have been unable to determine which $C'$ factor cortisone acetate inhibits, for, although we have chosen this form of cortisone for its relatively good water solubility, it could not be satisfactorily removed from the sheep erythrocytes by centrifuging and washing. But we have assured ourselves that the hæmolysis-preventing action of cortisone acetate is due to its action on $C'$, and is not an aspecific protection against hæmolysis (as is the case with cholesterol[11]). Cortisone acetate, aspirin, sodium salicylate and quinine do not protect sheep erythrocytes against hæmolysis by saponin, digitonin, or dodecyl sulphate.

Work on the action of aspirin and other substances on human $C'$ *in vitro* and *in vivo*, and on guinea pig $C'$ *in vivo*, is still in progress; but it can already be concluded, in the light of the results mentioned, and in view of the work of Osler *et al.*[3], that the action of aspirin on $C'$ can quite satisfactorily explain its multiple therapeutical benefits in various pathological states such as allergy, rheumatism and fever. Thus, quantitative estimations of this type of therapeutical activity of a great many existing and new compounds may quite easily be obtained through simple complement-hæmolysis reactions.

We are indebted to the frequent and fruitful discussions we had with Dr. A. Eyquem of the Pasteur Institute, Paris.

*Note added in proof.* $4 \times 10^{-4}$ aspirin has since proved active against much higher $C'$ concentrations *in vitro*. This anti-complementary action, and the lack of it in the case of salicylate, has been confirmed *in vivo*.

C. J. VAN OSS
J. C. FRIEDMANN
M. FONTAINE

Laboratory of Physical Biochemistry,
National Veterinary College,
Alfort (Seine).

[1] Schwab, L., Mole, F. C., Hall, T., Breen, H., Kirk, M., van Zandt-Hawn, C., and Haneway, C. A., *J. Exp. Med.*, **91**, 505 (1951).
[2] Zanussi, C., and Iuvernizzi, F., *Boll. First Sieroterap. Milan*, **37**, 192 (1958).
[3] Osler, A. C., Hawrisiak, M. M., and Ovary, Z., *Fed. Proc.*, **16**, 428 (1957).
[4] Büsing, K. H., *Allergie und Asthma*, **3**, 15 (1957).
[5] Schmidt, H., "Die Konglutination: Das Komplement", 31 (Dr. Dietrich Steinkopff Verlag, Darmstadt, 1959).
[6] Gross, M., and Greenberg, L. A., "The Salicylates" (Hillhouse Press, New Haven, 1948).
[7] Roskam, J., *Acta Clin. Belg.*, **3**, 305 (1948).
[8] Mayer, M. M., Levine, L., Rapp, H. J., and Marucci, A. A., *J. Immunol.*, **73**, 443 (1954).
[9] Kabat, E. A., and Mayer, M. M., "Experimental Immunochemistry", 123 (C. C. Thomas, Springfield, Ill., 1958).
[10] Work on more or less related compounds by Mills, S. E., and Levine, L., *Immunology*, **2**, 368 (1959), has recently come to our notice; in the light of this work a reversible inhibition of $C_3'$ appears more likely.
[11] Ponder, E., *J. Gen. Physiol.*, **28**, 349, 357 (1945).

### Possible Sources of Tartronate Deficiency in Man

SINCE exogenous tartronate (hydroxymalonate) is probably essential for the nutrition of rats[1], it has been suggested[2] that prolonged deficiency of available tartronate might result also in metabolic disturbances in man. Tartronate, which is produced only by plants[3], has chemical and physiological properties which could result in its becoming deficient in human diets. These properties are: (*a*) easy decarboxylation in hot, slightly acid solution; (*b*) complete

solubility in water; and (*c*) a relatively rapid rate of excretion. In the present work these sources of loss have been examined.

The loss of tartronate caused by decarboxylation may be attributed to the heating of acid foods during their preparation for consumption. To measure this effect, the homogenized samples were heated 1 hr. at 100° C., while the controls were alkalinized to *p*H 9 before the heating to prevent decarboxylation. The samples were cooled to room temperature, and the *p*H of the controls was brought back to the original value. Each was then analysed[4] for tartronic acid (Table 1). Losses were about 20 per cent for acid foods and insignificant for neutral and alkaline foods.

Table 1. Loss of Tartronate (TA) resulting from 1-hr. Heating with Water at 100° C. of a Number of Animal and Vegetable Tissues

| Tissue | Sample *p*H | Unalkalinized (mgm. TA/gm.) | Alkalinized (mgm. TA/gm.) | Loss TA (per cent) |
|---|---|---|---|---|
| Apple | 4·0 | 2·78 | 3·27 | 15 |
| Rolled oats | 5·7 | 0·07 | 0·09 | 22 |
| Potato | 5·8 | 0·21 | 0·46 | 33 |
| Corn meal | 5·9 | 0·14 | 0·18 | 22 |
| Tartronate | 6·0 | 0·82 | 0·93 | 14 |
| Rice, brown | 6·3 | 0·25 | 0·30 | 17 |
| Haddock | 6·6 | 0·03 | 0·04 | 25 |
| Milk, raw | 6·7 | 0·25 | 0·27 | 7 |
| Beefsteak | 6·9 | 0·15 | 0·16 | 6 |
| Egg yolk | 9·1 | 0·04 | 0·04 | 0 |
| Egg white | 9·1 | 0·11 | 0·12 | 6 |

Oxidation by air during heating was eliminated as a factor, since no differences were found between evacuated and non-evacuated samples.

Discarding the water in which vegetables have been boiled results in the loss of considerable tartronate. For example, a peeled half (72 gm.) of a medium-sized potato, without further cutting, was boiled 30 min. in a covered beaker with 125 ml. of water. At the end of that time the total weight of tartronate in the potato was 5·0 mgm., while that in the water was 5·7 mgm. Thus, half the tartronate remaining after decarboxylation would have been discarded.

Volatilization with steam is relatively slight (approximately 0·06 mgm./100 gm.).

Urinary tartronate excretion was measured in serial 2-hr. samples for 12 hr. following meals containing: (*a*) about 20 mgm. and (*b*) about 650 mgm. of tartronic acid. Each meal was eaten following a 12-hr. fast. The urine samples were alkalinized to *p*H 9, evaporated to about 15 ml. and analysed for tartronic acid[4] (Table 2). The excretion-rate in this work, about 10 mgm. per 12-hr. period, was essentially the same for both meals, but represented a large fraction of the tartronate in the low-tartronate meal.

Tartronate in a stool sample was found to be about five times as concentrated as in the urine (0·028 mgm. versus 0·005 mgm. per gm.).

Table 2. Urinary Excretion of Tartronic Acid (TA) following a Meal containing: (*a*) about 20 mgm. and (*b*) about 650 mgm. TA

| Period (2 hr.) | (*a*) (mgm. TA/2 hr.) | (*b*) (mgm. TA/2 hr.) |
|---|---|---|
| First | 1·80 | 3·06 |
| Second | 2·27 | 2·02 |
| Third | 1·44 | 1·80 |
| Fourth | 2·03 | 0·71 |
| Fifth | 0·63 | 1·46 |
| Sixth | 1·57 | 1·73 |
| Total | 9·74 | 10·98 |

Clear metabolic abnormalities are produced within two months in young rats on a tartronate-free diet, indicating that in this species, at least, exogenous tartronate may be essential to normal nutrition[1]. The first effect noted is the gradual rise in the carbohydrate-assimilatory respiratory quotients to values significantly greater than 1·00 (refs. 1, 5), accompanied by increasing obesity[1]. Minimal amounts of tartronate reduced these quotients to less than 1·00 (ref. 1). After about twelve months on the tartronate-free diet, the carbohydrate-assimilatory respiratory quotients were appreciably below 1·00 and fat formation no longer occurred[5], presumably because insulin was no longer as available for the early stages of carbohydrate catabolism. At this late stage no evident effect follows tartronate feeding. If, however, insulin is injected at the time of the test meal, high respiratory quotients are again found. A few days feeding of small amounts of tartronate can suppress this insulin effect[5]. These results and a number of low glucose tolerances suggest that at this stage an absolute or relative deficiency of insulin has supervened[5].

On the basis of results obtained with calf heart muscle, the following hypothesis has been suggested to interpret the above observations: tartronate may be a coenzyme of oxalosuccinic carboxylase in the citric acid cycle[2]; thus its deficiency in the body could result in a tendency to accumulate acetyl coenzyme *A*; much of this intermediate would be converted to fatty acids and cholesterol, requiring an abnormal amount of reduced triphosphopyridine nucleotide[6]; to supply this reduced triphosphopyridine nucleotide, an abnormal amount of glucose would have to be catabolized by the pentose phosphate route, which would require an excessive amount of insulin[7] and simulate in this respect the metabolic consequences of over-eating. If this accretion is sufficiently prolonged, disorders of the endocrine control of carbohydrate metabolism may be induced.

Whether tartronate is essential to human nutrition and, if so, whether it is possible for deficiencies to occur, are unknown, although the analogy of the obese, tartronate-deficient rat to human metabolic conditions may be significant. That losses of tartronate consistent with a mild to moderate deficiency can occur in man has been shown in this communication.

Laurence G. Wesson

Laboratory for Insulation Research,
Massachusetts Institute of Technology,
Cambridge 39, Mass.

[1] Wesson, L. G., *Endocrinol.*, **47**, 302 (1950).
[2] Wesson, L. G., *Science*, **122**, 595 (1955).
[3] Rieben, W. K., and Hastings, A. B., *Helv. Physiol. et Pharmacol. Acta*, **4**, C52 (1946).
[4] Wesson, L. G., *Anal. Chem.*, **30**, 1080 (1958).
[5] Wesson, L. G., *Endocrinol.*, **29**, 900 (1941).
[6] Brady, R. O., Mamoon, A., and Stadtman, E. R., *J. Biol. Chem.*, **222**, 795 (1956). Langdon, R. G., *J. Biol. Chem.*, **226**, 615 (1957).
[7] Silperstein, M. D., *Diabetes*, **7**, 181 (1958); **7**, 219 (1958).

## A New Green-Leaf Growth-stimulating Factor, Phyllococosine, from Coconut Milk

Kinetin[1,2] and gibberellin[3] are known to accelerate the growth of green leaf disks floated on a medium containing one of these substances. A growth factor that stimulates leaf growth has now been discovered in coconut milk.

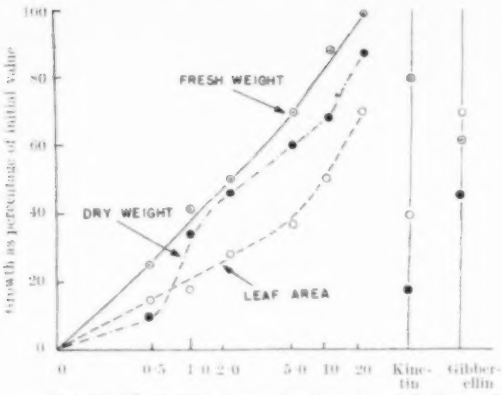



Fig. 1. Effect of coconut milk on the growth of green leaf disks. Leaf disks were incubated at 25° C. for 12 hr. under illumination of 1,000 lux. The two lines on the right show the optimum growth produced by kinetin (refs. 1 and 2) or gibberellin (ref. 3)

*Raphanus sativus* L. var. *acantiformis* Makino was cultured in pots in the field[1,2]. When the first foliage leaves became about 0·4–0·5 cm.² in size, the pots were transferred to the dark room to increase the sensitivity of the tests, and kept there for about 24 hr. After this period, disks were punched out from the middle of the leaves with a cork borer (0·5 cm. in diameter), and each lot of fifteen disks was floated on 10 ml. of the culture solution[1,2] in Petri dishes (5 cm. diameter) and then incubated at 25° C. for 12 hr. under 1,000 lux of illumination from fluorescent tubes. The fresh weight, dry weight and leaf area of the leaf disks incubated with coconut milk were greater than those of kinetin- or gibberellin-treated disks (Fig. 1).

Growth comparisons between the media containing various concentrations of coconut milk in the presence of optimum concentrations of kinetin (1·0 mgm./l.) (ref. 1) or gibberellin (10·0 mgm./l.) (ref. 3) indicated that both gibberellin and kinetin have a synergistic effect with coconut milk (Fig. 2). When coconut milk was mixed with an equal volume of 0·1 *N* acetic acid, 0·1 *N* hydrochloric acid or 0·1 *N* sulphuric acid, and kept in the cold for 12 hr. in the dark, a considerable loss in activity resulted. The leaf-growth factor in coconut milk did not dissolve in ethyl ether, petroleum ether, benzene, chloroform or anhydrous acetone. All these facts indicate that this leaf-growth factor is different from kinetin or gibberellin.

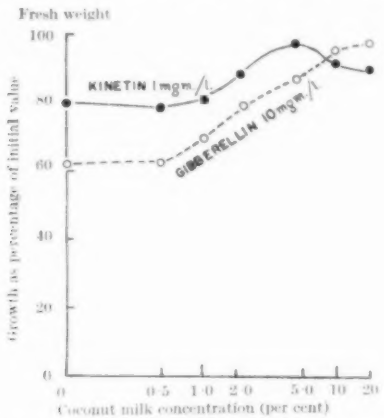



Fig. 2. Synergistic effect of coconut milk and kinetin or gibberellin. Leaf disks were incubated at 25° C. for 12 hr. under illumination of 1,000 lux

The leaf-growth factor was purified according to the scheme shown in Fig. 3, and a preparation about 2,000 times more active on a dry-weight basis than the starting material was obtained.

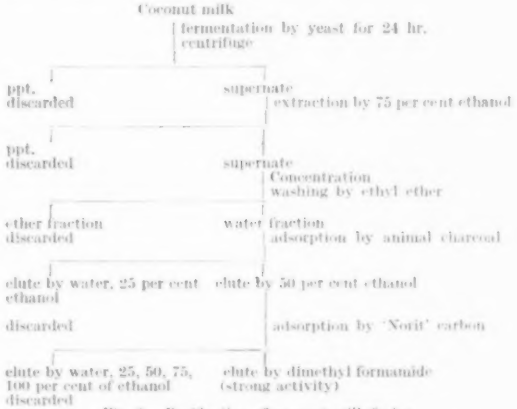



Fig. 3. Purification of coconut milk factor

The cell-division factor from coconut milk has been extensively purified[4] and the activity has been reported to be precipitated with mercuric or lead acetate. The leaf-growth promoting factor lost its activity on treatment with these compounds (hydrogen sulphide was added to remove the excess mercuric or lead ion).

We conclude that this leaf-growth factor in coconut milk is a new growth factor and propose to name it 'phyllococosine'.

We thank Prof. T. Yamaki, of the University of Tokyo, for his criticisms.

SUSUMU KURAISHI*

Biological Institute,
College of General Education,
University of Tokyo,
Komaba, Meguro, Tokyo.

F. SHIGEO OKUMURA

Department of Chemistry,
Faculty of Engineering,
University of Tokushima,
Tokushima, Japan.

* Present address: Department of Biochemistry, University of Wisconsin, Madison, Wisconsin.

[1] Kuraishi, S., and Okumura, F. S., *Bot. Mag. Tokyo*, **69**, 300 (1956).
[2] Kuraishi, S., *Sci. Pap. Col. Gen. Educ. Univ. Tokyo*, **9**, 67 (1959).
[3] Kuraishi, S., and Hashimoto, T., *Bot. Mag. Tokyo*, **70**, 86 (1957).
[4] van Overbeek, J., Conklin, M. E., and Blakesley, A. F., *Science*, **94**, 350 (1941). Mauney, J. R., Hillman, W. S., Miller, C. O., Skoog, F., Clayton, R. A., and Strong, F. M., *Physiol. Plantarum*, **5**, 485 (1952). Shantz, E. M., and Steward, F. C., *J. Amer. Chem. Soc.*, **74**, 6133 (1952); **77**, 6351 (1955).

## Differential Sublimation Rates of Light and Tritium-labelled Water

WATER is an important component of the body, and the only one that can be measured directly. Body water is also useful, however, to obtain an estimate of body fat. Body water plus body density information enables one to estimate body fat with a precision of approximately 2–4 per cent when the following equation is used :

$$\text{Percentage fat} = \frac{(2{\cdot}118\ D - 0{\cdot}780\ TBW - 1{\cdot}354)}{\times 100}$$

where $D$ is the density of the body, and $TBW$ is the total body water, as a proportion of body weight[1].

A valid and reliable method for measurement of total body water with a liquid scintillation spectrometer was sought in order to evaluate changes in body composition in man which occur as the result of restriction of calories and other experimental regimens. Others[1,2] have reported that tritium may be used successfully as a solute to determine total body water. The method depends on vacuum sublimation of tritium-labelled plasma to obtain suitable samples of plasma water for liquid scintillation radioassay. Since sublimation to virtual dryness requires one or more hours, it was felt that time might be saved if a shorter collection period would give the same specific activity as complete sublimation. Credence was attached to this approach because it has been observed that distillation of urine containing tritium in specially shaped vessels failed to produce a significant difference in isotope concentration in serial distillation samples[3]. When the procedure for vacuum distillation[2] was sequentially interrupted and fractional collections were obtained, it became apparent that progressive tracer enrichment of the sublimate occurred. Further, the geometry of the glassware used for sublimation altered the rate of enrichment. Although the phenomenon of tracer enrichment has long been known and has been effectively used for isotopic separation by fractionation[4], it seems important to direct attention now to this significant source of error in incomplete sublimation in view of increasing interest in determinations of body composition.

A sample of tritium-labelled water of known concentration was placed inside a Florence flask (first apparatus), which was then rotated in a dry ice and ethanol bath to freeze the sample in the shape of a thin spherical shell. The flask was connected to a vacuum system in which vapour released from the sample was collected by a trap immersed in dry ice and ethanol. The vapour trap was frequently replaced by a new one, and whatever ice had collected in each vapour trap was melted, removed, mixed, and radioassayed with a liquid scintillation spectrometer. The total procedure was repeated twice, and the normalized average results are given in Table 1*A*.

The sublimation procedure was also repeated in a second apparatus, the sample vessel of which was tubular rather than spherical. The sample was frozen in this vessel in the shape of a solid cylinder rather than a hollow sphere. With this second apparatus, the ratio of exposed area to sample volume was such that the sample melted before sublimation was completed. Later fractions were therefore condensates of the evaporated vapour from the liquid sample. The sublimation was repeated twice, and the normalized average results are given in Table 1*B*.

Table 1*A* indicates that on the average as the sublimation proceeded, each sublimate fraction contained an increasing concentration of tritium. The sample taken at the beginning of the sublimation had the lowest specific radioactivity, and the sample taken at the end of the sublimation showed the highest specific radioactivity (arbitrarily designated 100 per cent). The mean percentage difference between the first and last collection was 8 per cent.

Table 1. Results of Three Separate Sublimations (*a*, *b*, *c*) with Each of Two Apparatus Models

*A*, First apparatus (spherical flask)

| Sublimation fraction → | 1 | | 2 | | 3 | | 4 | |
|---|---|---|---|---|---|---|---|---|
| | *C* mμc./gm. | *N* % | *C* | *N* | *C* | *N* | *C* | *N* |
| Sublimation mixture *a* | 9·09 | 93 | 9·20 | 94 | 9·54 | 98 | 9·73 | 100 |
| *b* | 50·2 | 92 | 52·4 | 96 | 50·0 | 91 | 54·8 | 100 |
| *c* | 50·2 | 91 | 50·5 | 92 | — | — | 55·0 | 100 |
| Mean percentage | | 92 | | 94 | | 95 | | 100 |
| Time (min.) | | 10 | | 34 | | 51 | | 92 |

*B*, Second apparatus (tubular flask)

| Process → | Sublimation | | | Melting | Evaporation | | |
|---|---|---|---|---|---|---|---|
| Sublimation fraction → | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| Sublimation mixture *a* | 95% | 95% | 100% | 92% | 90% | 95% | 100% |
| *b* | 86 | 91 | 100 | 97 | 93 | 97 | 95 |
| *c* | 96 | 96 | 95 | — | 96 | 99 | 100 |
| Mean percentage | 92 | 96 | 98 | 95 | 93 | 97 | 98 |
| Time (min.) | 16 | 32 | 52 | 68 | 83 | 107 | Residue |

Each value represents the mean radioassay of five aliquots of each sublimation fraction. Values are in percentages of the most radioactive sample (rounded to two significant figures). *C*, mean concentration of tritium found, in mμc. per gm. of sample; *N*, normalized mean concentration of tritium (per cent); time, mean time elapsed from the beginning of the sublimation to the termination of collection of each fraction, in minutes.

Thus, the maximum variation from the mean concentration for the entire collection was 4 per cent. Estimated total body water would therefore vary by 4 per cent if only the results from the first collection were used for the estimation.

Table 1*B* also indicates that on the average the concentration of tracer in the sublimed fractions increased with time of collection, for the first three fractions. During the collection of fraction 4, the sample melted and the liquid sample bubbled, so that the sample was physically re-mixed. The majority of the trapped specific activity from fractions five to seven was condensed from the vapour of the liquid sample, and again showed a progressive increase with time. Comparison of Tables 1*A* and *B* reveals that the variation of specific activity with time depended on the geometry of the system. Results were highly variable with the second apparatus.

In summary, one cannot predict in advance from the shape of the sample flask what the concentration of tracer in a particular fraction of the sublimate might be; but it is apparent that the concentration of tracer in a single fraction is not likely to be representative of the concentration in the total volume recovered from the sample. Errors in the sublimation are minimized by removing as much water as possible from the sample of biological fluid subjected to the sublimation procedure. Alternatively, in order to save time, a correction curve might be determined for a specific sublimation procedure, if it should be desirable to obtain only a partial sublimate for radioassay. To simplify interpretation of such a correction curve, the ratio of surface to volume of the frozen sample should be relatively large, as in a spherical

flask, in order to secure reproducible results. The difference between the value of mean specific activity obtained from a correction curve and from total sublimation should be no more than 2 per cent, whereas using only the first collection from the spherical flask the variation was 4 per cent. Although it might have been predicted that an enrichment effect would have been observed both because of (1) the difference in vapour pressure of tritium-labelled water and light water at given temperature and pressure[5], (2) Graham's law, in practice this enrichment effect may or may not[3] be found, depending on the apparatus and conditions for sublimation or evaporation.

R. Moore
E. R. Buskirk

Metabolic Diseases Branch,
National Institute of Arthritis
and Metabolic Diseases,
National Institutes of Health,
Bethesda, Maryland.

[1] Siri, W. E., "Body Composition from Fluid Spaces and Density: Analysis of Methods", 22 (UCRL-3349) (March 1956).
[2] Cooper, J. A. D., Radin, N. S., and Borden, C., *J. Lab. Clin. Med.*, **52**, 129 (1958).
[3] Simpson, J. D., and Greening, J. R., *Nature*, **186**, 467 (1960).
[4] Urey, H. C., Brickwedde, F. G., and Murphy, G. M., *Phys. Rev.*, **40**, 1 (1932).
[5] Price, A. H., *Nature*, **181**, 262 (1958).

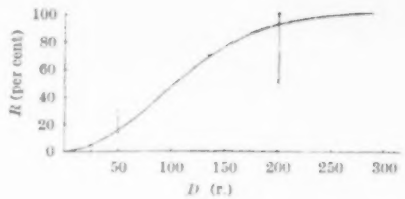


Fig. 1

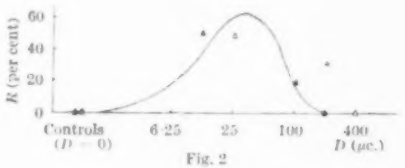


Fig. 2

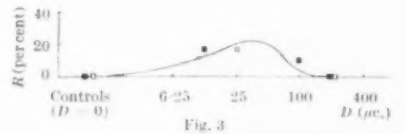


Fig. 3

## RADIOBIOLOGY

### Dose–Response Relationship in Radiation Carcinogenesis

The question whether the dose–response relationship for neoplasia induced by ionizing radiations is linear or non-linear, and with or without a threshold dose, is one of the most important problems in both basic and applied radiobiology[1].

From the experimental knowledge now available[2], and especially from the results of chromosome work of the past few years, more and more evidence indicates that in all forms of neoplasia the key step is an irreversible change in the genetic apparatus of the somatic cells, that is, a somatic mutation, consisting in cytogenetical loss caused by interference with the synthesis and functions of the deoxyribonucleic acid of the chromosomes, leading, presumably, to the deletion of growth-controlling and/or regulatory proteins as well as to the loss of tissue-specific antigens.

It has generally been tacitly assumed that this somatic mutation hypothesis for induced carcinogenesis implies a linear dose–response relationship for small doses. However, it has been pointed out (see, for example, refs. 3 and 4) that this is not correct, but that the somatic mutation hypothesis may lead to non-linear dose–response relationships when the effects are taken into account of such phenomena as indirect free-radical energy transfers, the toxicity of the carcinogenic agents which kill certain of the cells, the various adaptive mechanisms of the cells whereby they defend themselves against the carcinogenic potency of the agents, such as reunion of broken chromosomes, production of antibodies, physiological recovery factors, inter- and intra-molecular transfers of ionization-electrons and excitation energies, and so forth[5].

Thus, from a direct one-hit form of the somatic mutation hypothesis previously worked out[3,6], it follows that for radiation carcinogenesis the response $R$ (fraction of animals showing at least one tumour among a test sample) is a function of the applied dose $D$ (in arbitrary units) given theoretically by:

$$R = 1 - \exp\left[-\frac{k\exp\left[-\mu D\right]D}{\alpha}\right], \quad \alpha = \alpha_e + \alpha_a \quad (1)$$

Here $k$ is the specific carcinogenicity constant measuring the carcinogenic potency of the agent for given species of test animal, genotype, phenotype, tissue and type of tumour; $\mu$ is the toxicity constant measuring the degree of toxicity of the agent; $\alpha_e$ is the elimination constant measuring, in the case of radiation from internally applied radioisotopes, the physical decay and metabolic elimination of the agent; $\alpha_a$ is the adaptation constant measuring the degree of adaptive power of the cells.

Whether a threshold dose exists or not in radiation carcinogenesis cannot be decided experimentally but only on theoretical grounds, as pointed out by Mole[4]. We see from equation (1) that no threshold is required in the direct one-hit form of the somatic mutation hypothesis. However, as shown below and in Figs. 1–3, the existence of such a threshold may be simulated in certain cases by the fact that the form of equation (1) may lead to such small values of $R$ for small doses that they are unobservable in the small samples of test animals generally used in experimental carcinogenesis.

For increasing radiation doses, the defence mechanisms of the cells may be expected to be interfered with and weakened, and thus the adaptation constant $\alpha_a$ will, presumably, decrease with increasing doses. If, tentatively, we make the simple assumption about this variation that $\alpha_a$ is inversely proportional to the dose $D$:

$$\alpha_a = \beta/D \quad (2)$$

we get dose–response curves which, for $\alpha_e \ll \alpha_a$, show sigmoid form, varying for small doses as $D^2$, and for $\alpha_e \gg \alpha_a$ are linear for small doses. Inserting (2) into (1), we can calculate the theoretical dose–response

curve and compare it with experimental values by graphical fitting of the three parameters $\alpha_s/k$, $\beta/k$, and $\mu$. (The value of the parameter $k$ can be obtained when the induction-time versus dose curve is fitted.) In Fig. 1 we show as an example $R = R(D)$ with $\alpha_s = 0$, $\mu = 0$, and $k/\beta = 6{\cdot}4 \times 10^{-5}$ fitted to the experimental values of Deringer *et al.* discussed by Mole[4]. In Figs. 2 and 3 we show as two other examples $R = R(D)$ with $\alpha_s = 0$, $\mu = 0{\cdot}06$, and $k/\beta = 6{\cdot}4 \times 10^{-5}$ and $\frac{1}{4} \times 6{\cdot}4 \times 10^{-5}$, respectively, fitted to the experimental values of Lindsay *et al.* discussed by Mole[4].

We see from Figs. 1–3 that the direct one-hit form of the somatic mutation hypothesis actually leads to a sufficiently flexible dose–response curve—without, but in some cases simulating, a threshold—which can be fitted with qualitative agreement to experimental values showing not only a linear form, but also a sigmoid form, and a form with a maximum. Thus radiation carcinogenesis does not even theoretically show one and the same form of the dose–response curve common to all cases, but the form varies from case to case, depending on the experimental conditions and the relative importance of the effects of toxicity, elimination and adaptation in each specific case.

More detailed experimental knowledge elucidating directly the *toxicity* effect, the *elimination* effect, and the *adaptation* effect is, therefore, necessary in each case before reliable conclusions can be drawn regarding the form of the dose–response relationship and its further application, such as for estimations of radiation hazards.

Niels Arley
Reidar Eker

Norsk Hydro's Institute for Cancer Research,
Radiumhospitalet, Norway.

[1] Report of the United Nations Scientific Committee on the Effects of Atomic Radiation (New York, 1958).
[2] Huxley, "Biological Aspects of Cancer" (Allen and Unwin, London, 1958). Boyland, ed., *Brit. Med. Bull.*, **14**, No. 2 (1958). Strong, ed., *Ann. New York Acad. Sci.*, **71**, Art. 6 (1958). Wolstenholme and O'Connor, ed., "CIBA Foundation Symposium on Carcinogenesis. Mechanisms of Action" (Churchill, London, 1959). Levan, Statens Naturvetenskapliga Forskningsråds Årsbok, **12**, 212 (Stockholm, 1959). Bayreuther, K., *Nature*, **186**, 6 (1960).
[3] Arley and Iversen, *Acta Path. Microbiol. Scand.*, **33**, 133 (1953); see p. 143.
[4] Mole, *Brit. Med. Bull.*, **14**, 188 (1958).
[5] Bacq and Alexander, "Fundamentals of Radiobiology" (Butterworth, London, 1955); see especially Chapter 11.
[6] Arley and Iversen, *Nature*, **169**, 410 (1952). Iversen and Arley, *ibid.*, **171**, 257 (1953). Arley, Proc. Fourth Berkeley Symposium on Mathematical Statistics and Probability (Berkeley, in the press). Eker and Arley, "Adv. Biol. Med. Phys." (in the press).

## Action of Neurohypophyseal Hormones on the Sodium Fluxes of a Freshwater Teleost

The presence of hormones showing oxytocic and vasopressic activities in the neurohypophysis of teleosteans has been known for some time[1]. The intervention of the hypothalamo–hypophyseal complex in the regulation of the hydro-mineral balance in teleosteans has been recently proposed as a result of histological studies on neurosecretion[2]. The biological role of the hormones secreted by this complex, however, remains unknown: no antidiuretic or water-balance effect has been shown in these animals[3]. On the other hand, teleostean neurohypophyseal extracts are known to be active in certain Amphibia not only on the water metabolism[4], but also on the active sodium transport exhibited by the skin[5]. The object of the present work was to study whether, failing a clear-cut effect on water metabolism, the role of these hormones in fish is in fact concerned with sodium exchange across the gills.

The experiments were carried out on the freshwater teleost *Carassius auratus* L. The net flux, influx and outflux of sodium in a freshwater fish can be calculated by a quantitative analysis of the changes in the external medium over a period of time of the concentrations of sodium-23 and -24 added as a tracer[6]. These determinations were made over a short range of time (8 hr.) so that the radioactive outflux of the fish could be considered as negligible in the calculations. The experiments were carried out on four groups, each of six fishes (average weight of a fish, 80 gm.), placed in aerated aquaria containing 4 l. of running tap-water. The determinations of the sodium fluxes were carried out simultaneously in the four aquaria over a period of one month (March–April 1960). Each week, one of the groups acted as a control, the fishes receiving injections of a 0·9 per cent aqueous solution of sodium chloride, while the other groups received hormonal extracts. On successive weeks, different groups of fish were chosen as controls. Of the groups of fish receiving hormonal extracts, at least one was injected with acetic extract of acetonic powder of *Carassius* hypophysis (equivalent to 1 mgm. of dry powder containing 60 mU. oxytocic activity[7] per animal), or with a similar extract of *Carassius* neurohypophysis (0·1 or 0·2 mgm. powder containing 45 or 90 mU. oxytocic activity per animal). The remaining groups received either synthetic oxytocin ('Syntocinon', Sandoz) at doses of 150 mU. or 1 U. per animal, or vasopressin ('Pitressin', Parke-Davis) at doses of 400 mU. per animal.

Fishes show a marked 'shock-effect' at any disturbance, which results in an upset of their mineral balance[6,8,9], to avoid which certain precautions had to be adopted in all experiments. The fish had had 15 days adaptation in the experimental aquaria before the beginning of the measurements, and the aquaria were isolated from laboratory disturbances by a screen. The addition of radiosodium (after stopping the water circulation) and the removal of water samples every 2 hr. were carried out by remote control. Finally, the intra-muscular injections were made 17 hr. before the flux determinations.

The results are shown in Fig. 1 and Table 1. In Fig. 1, the changes with time in the external radiosodium concentration are shown on the left, and those of the external sodium-23, measured by flame-photometry, on the right. In all the experiments, these relationships were linear functions. A comparison of the regression lines corresponding to the four groups when acting as controls (black circles) with those when the groups had been treated with *Caras-*

Table 1. Action of *Carassius* Hypophyseal Extracts and of Mammalian Hormones on the Sodium Fluxes of *Carassius auratus*

| | Doses | No. of determinations | Influx (μgm./hr.) | Net flux | Outflux |
|---|---|---|---|---|---|
| Controls | — | 4 | 149 ± 33* | − 13 ± 27 | 162 ± 27 |
| *Carassius* extracts | 45–90 mU. (oxytocic) | 4 | 325 ± 7 | + 181 ± 19 | 144 ± 13 |
| Oxytocin | 150 mU. | 2 | 290 | + 5 | 285 |
| | 1 U. | 1 | 372 | + 162 | 210 |
| Vasopressin | 400 mU. | 1 | 231 | + 37 | 268 |

* S.E.

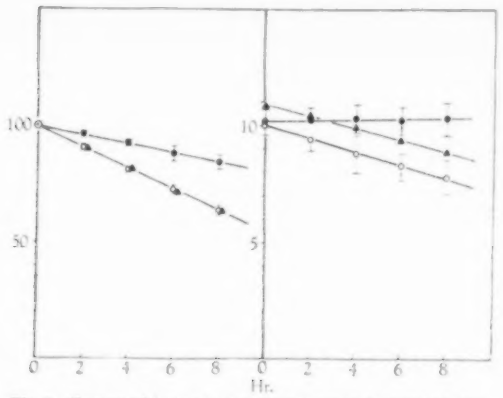



Fig. 1. Changes with time in the external media of fishes injected with neuro-hormonal extracts. Left, changes in the sodium-24 concentration (in per cent of the initial radioactivity); right, changes in the concentration of sodium-23 (μgm./ml.). Black circles, controls; white circles, after injection with *Carassius* hypophyseal extracts; black triangles, after injection with 1 U. oxytocin. The standard error of the measurements is indicated

*sius* extracts (white circles) shows that the slopes are significantly different for both sodium-23 and -24. In the controls, the net flux per animal is around zero: $f_{net} = -13 \pm 27$ (*S.E.*) μgm./hr., while the influx is $149 \pm 33$ μgm./hr. After injection with the *Carassius* extracts, the concentration of external sodium-23 falls in all the groups, indicating a positive net flux: $+181 \pm 19$ μgm./hr., while the average influx becomes $325 \pm 7$ μgm./hr. These increased fluxes are significantly different from the control values ($t = 5{\cdot}9$ and $P < 0{\cdot}001$ for $f_{net}$; $t = 5{\cdot}35$ and $P = 0{\cdot}001$ for the influx). The sodium outflux, that is $f_{in} - f_{net}$, on the other hand, remains unchanged: $f_{out} = 144 \pm 13$ in the treated fish, compared with $162 \pm 27$ μgm./hr. in the controls ($t = 0{\cdot}55$ and $P = 0{\cdot}6$).

The injection of oxytocin (1 U. per animal) results in an effect comparable with that obtained after injections with *Carassius* extracts. The change in external radiosodium concentration (black triangles) is identical and the slope of the linear regression line, indicating the change in concentration of external sodium-23, is similar to that obtained after hypophyseal extract injections.

Thus both *Carassius* hypophyseal and neurohypophyseal extracts and oxytocin stimulate the influx of sodium and, the outflux remaining unchanged, the result is a net uptake of sodium. The action of these hormones on the gills of teleosts is thus identical with their action on the skin of Amphibia: that is, the hormones stimulate the active influx of sodium against the concentration gradient, while the passive outflux remains unaffected.

The results given in Table 1 show that only *Carassius* extracts and oxytocin produce a clear-cut increase in sodium uptake, and that the extracts are much more active than would be expected from their actual oxytocic activity. On the other hand, vasopressin has very little activity. It would seem probable, therefore, that the neurohypophyseal principles of the fish, which are active in the mineral metabolism, are different from the mammalian neurohypophyseal hormones. The same conclusion has already been advanced by Maetz *et al.*[5] from a comparison of the activities of the hypophyseal extracts of various teleosteans with those of mammalian hormones on the active transport of sodium across frog skin ('natriferic activity'). From various investigations on the 'water-balance effect' in the frog, Heller[4], and more recently Pickering and Heller[10], Sawyer *et al.*[11], Sawyer[12], conclude that in amphibians and teleosts a 'water-balance principle' occurs, which is different from any of the mammalian hormones. Nevertheless, the biological role of the new hormone(s) would appear to be related, in any event in the teleosts, much more to the sodium than to the water exchange.

J. Maetz
M. Juien

Département de Biologie,
Commissariat à l'Energie Atomique,
Saclay par Gif-sur-Yvette,
Seine et Oise.

[1] Pickford, G. E., and Atz, J. W., "The Physiology of the Pituitary Gland of Fishes" (Zool. Soc., New York, 1957).
[2] Arvy, L., and Gabe, M., *C.R. Assoc. Anat.*, **41**, 843 (1954).
[3] Fontaine, M., "The Hormonal Control of Water and Salt Electrolyte Metabolism in Fish", *Memoirs of the Soc. Endocrinology*, **5**, 69 (1956).
[4] Heller, H., *Experientia*, **6**, 368 (1950).
[5] Maetz, J., Morel, F., and Lahlouh, B., *Nature* (Supp.), **184**, 1236 (1959).
[6] Maetz, J., *J. Physiol., Paris*, **48**, 1085 (1956).
[7] Holton, P., *Brit. J. Pharmacol.*, **3**, 328 (1948).
[8] Krogh, A., "Osmotic Regulation in Aquatic Animals" (Cambridge Univ. Press, 1939).
[9] Meyer, D. K., *Amer. J. Physiol.*, **165**, 580 (1951).
[10] Pickering, B. T., and Heller, H., *Nature*, **184**, 1463 (1959).
[11] Sawyer, W. H., Munsick, R. A., and van Dyke, H. B., *Nature*, **184**, 1465 (1959).
[12] Sawyer, W. H., *Endocrinol.*, **66**, 112 (1960).

## CYTOLOGY

### Implication of Chromosome Structure and Replication on Hazard of Tritiated Thymidine and the Interpretation of Data on Cell Proliferation

Labelling of chromosomal deoxyribonucleic acid (DNA) with tritium-labelled thymidine ($H^3TDR$) demands consideration of the probabilities of long-term retention of the label and damage to somatic and genetic cells. These are important for the interpretation of results and for consideration of hazards associated with the use of tritiated thymidine in human beings. The model proposed by Taylor, Woods and Hughes[1] permits prediction of the persistence of the label, an implication which has not been adequately explored in previous publications by ourselves and others[2-4]. The model is based on autoradiographic observations on plant chromosomes labelled with $H^3TDR$ during replication. In this model each chromosome is considered to consist of two halves (chromatids), both of which replicate. If $H^3TDR$ is available during DNA synthesis for a finite period, both half-chromosomes will be labelled in their newly formed replicas. On division, all chromosomes of the daughter cells will contain the label in the newly replicated chromatid. Subsequent DNA synthesis proceeds without further availability of $H^3TDR$, and newly formed replicas of both labelled and unlabelled chromatids will be unlabelled.

In the daughter cells of the second division, on the average half the chromosomes will be labelled, each composed of one labelled and one unlabelled chromatid. After each subsequent division the number of labelled chromosomes per cell will be halved as the originally labelled chromatids become distributed among twice the number of cells. When the synchron-

ously dividing progeny of a labelled cell first exceeds the chromosomal number, the fraction of labelled cells will begin to diminish, since an increasing number of cells will contain a single labelled chromatid which cannot subdivide, but must go to one daughter cell, leaving the other totally unlabelled. The expected decrease has been computed on the basis of equal distribution among daughter cells and studied experimentally in a transplantable mouse tumour by Mendelsohn[5]. The only assumption made is the non-exchangeability of DNA. This is true at the molecular level. However, exchange of part of a labelled chromatid with the corresponding portion of its unlabelled replica has been demonstrated autoradiographically in plant cells[1]. This results in redistribution of the label among a larger number of chromosomes. The extent of crossing-over in somatic and genetic cells of man is not known, but it is unlikely to approach a random distribution, as would be expected of exchangeability on a molecular level.

If one accepts this model, disregarding crossing-over for the purpose of this discussion, it may be expected that the labelled chromosomes will be randomly distributed among the daughter cells at each mitosis. Assuming that the movement of each labelled chromosome to one or the other pole of the spindle is equally likely and independent of the movement of any other chromosome, the probability of occurrence $f_k(x)$ of cells with $x$ labelled chromosomes after $k$ generations can be shown to follow a binomial distribution:

$$f_k(x) = \binom{n}{x}\left(\frac{1}{2^{k-1}}\right)^x\left(1-\frac{1}{2^{k-1}}\right)^{n-x}$$

or

$$f_k(x) = \binom{n}{x}\frac{(2^{k-1}-1)^{n-x}}{2^{(k-1)n}}$$

where $n$ is the chromosome number. These discrete distributions have been computed for the human chromosome number 46 and are represented in Fig. 1 for the second to fifth division. In Fig. 1 the individual points $f(x)$ for each generation are joined for easier visualization. The most frequent number of labelled chromosomes per cell in successive generations is 23, 11, 5 and 2, the expected means being 23, 11·5, 5·75 and 2·87.

As can be seen from Fig. 1, about 5 per cent of cells have 0 labelled chromosomes after the fifth division. After the sixth division (not shown here), the most frequent number of labelled chromosomes is 1, and about 23 per cent of the progeny can be expected to be unlabelled. Without the influence of the random distribution of chromosomes, unlabelled cells would not appear until the seventh division. Thus, as the modal number of labelled chromosomes per cell approaches zero, the random distribution of chromosomes will favour an earlier appearance of unlabelled cells than the aforementioned decrease in the fraction of labelled cells due to the indivisibility of the originally labelled chromatids.

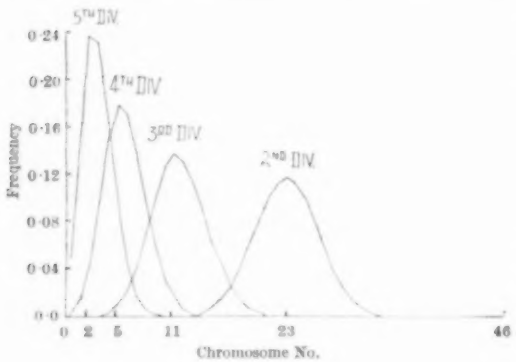


Fig. 1

Another feature of somatic cell proliferation is that a substantial portion of the progeny mature into non-proliferating cells which differentiate and die or are lost from the body, thus removing the labelled DNA.

The number of cells carrying the radioactive label in the DNA is thus continuously reduced in somatic proliferating systems such as marrow, lymphoid tissue and gastro-intestinal mucosa in three ways. There is continued loss of labelled material through death or loss of the non-dividing progeny of labelled cells; without consideration of random distribution of chromosomes, the percentage of labelled cells is reduced continuously in an exponential manner, once the progeny exceeds the chromosomal number, because the label is not homogeneously re-mixed with all the DNA during each doubling period; and the random distribution of labelled chromosomes among daughter cells favours an even earlier appearance of unlabelled cells among the progeny.

It has not been established that the model proposed by Taylor, Woods and Hughes pertains to mammalian chromosomes. It is now under study in tissue culture systems of human cells. If the expected agreement with the Taylor–Woods–Hughes model is confirmed, it will have a direct bearing on the interpretation of data in the study of cell proliferation, and the somatic and genetic hazard of $H^3TDR$ in long-term work.

Eugene P. Cronkite
Samuel W. Greenhouse
George Brecher
Victor P. Bond

Medical Research Center,
Brookhaven National Laboratory,
Upton, New York,
and
National Institutes of Health,
Bethesda, Maryland.

[1] Taylor, J. H., Woods, P. S., and Hughes, W. L., *Proc. U.S. Nat. Acad. Sci.*, **43**, 122 (1957).
[2] Hughes, W. L., Bond, V. P., Brecher, G., Cronkite, E. P., Painter, R. B., Quastler, H., and Sherman, F. G., *Proc. U.S. Nat. Acad. Sci.*, **44**, 476 (1958).
[3] Cronkite, E. P., Bond, V. P., Fliedner, T. M., and Rubini, J. R., *Lab. Invest.*, **8**, 263 (1959).
[4] Stohlman, jun., F., edit., "Kinetics of Cellular Proliferation" (Grune and Stratton, New York, 1959).
[5] Mendelsohn, M. L., *J. Nat. Cancer Inst.*, **25**, 485 (1960).

## Chromosome Anomaly in Two Cases of Cerebral Palsy, a Brother and a Sister

The unsolved question of the source of many human congenital anomalies has recently received great impetus from the cytological aspect. This is largely due to an improved chromosome spreading technique which led to the establishment of the correct chromosome number in man[1]. Further evidence that a change in chromosome number was responsible for the phenotypic expression of certain clinical entities[2] stimulated the application of this

Fig. 1. *A*, Normal male; *B*, affected male; *C*, normal female; *D*, affected female. The arrows indicate the position of the *X*-chromosome in order of size and shape in relation to the centromere. The position is sixth or seventh in the ideograms of the normal children and third or fourth in the ideograms of the affected children

approach to cases of cerebral palsy of unknown or so-called developmental etiology.

In the course of our investigation of the hereditary aspect of cerebral palsy a brother and a sister came to our notice. In addition to an unusual aspastic spastic type of cerebral palsy, these children also had congenital cataract of the nuclear and posterior capsular type. After intensive investigation of this family, a rare recessive autosomal type of inheritance was reported[2]. However, recent work on metaphase plates obtained from peripheral leucocytes grown in tissue culture by a modification of the Hungerford *et al.*[4] technique showed uniform counts of 46 chromosomes in both children. Ideogram arrangements (Fig. 1) of chromosomes according to position of centromere consistently demonstrated an abnormal morphological configuration of one of the larger chromosomes with a subterminal centromere. No apparent homologous chromosome could be established for this abnormal-looking chromosome in either the boy or the girl.

Ideograms of both cases were carefully analysed and compared with those obtained from normal children of the same sex and age. Inspection of these ideograms (Fig. 1) seems to place the long unpaired subterminal chromosome in the position of the *X*-chromosome in relation to the other autosomes. Of course, the difficulty of differentiating the *X*-chromosome from some of the other elements in the complement is well recognized by cytologists.

Since both parents are phenotypically normal, a translocation on the *X*-chromosome in the mother was considered as a possible mechanism responsible for the condition in the children. The *X*-chromosome in the boy must have come from the mother, and obviously the girl also received this particular *X*-chromosome from the mother. If this theory is correct, it must be assumed that this abnormality occurred in the mother in early embryological gonadal development.

The slightly greater degree of involvement demonstrable in the boy might be due to the heterozygous sex chromosome in the male. Presumably the girl received a normal *X*-chromosome from the father and conceivably this may make a slight difference in phenotypic expression. The fact remains that there is a striking similarity in the children as to their general physical and facial appearance, their motor and cataract involvement, their mental performance, as well as the presence of the same 'abnormal' chromosome.

We thank Dr. Mizutani for technical assistance.

J. Blumel
Y. Ohnuki*
A. Awa*

Department of Surgery,
Division of Orthopedics and the
Tissue Culture Laboratory,
University of Texas Medical Branch and the
Moody State School for Cerebral Palsied Children,
Galveston, Texas.

* Fellow of the Tobacco Industry Research Committee. Permanent address: Zoological Institute, Hokkaido University, Sapporo, Japan.

[1] Tjio, J. H., and Levan, A., *Hereditas*, **42**, 1 (1956). Ford, C. E., and Hamerton, J. L., *Nature*, **178**, 1020 (1956).
[2] Ford, C. E., *et al.*, *Nature*, **183**, 1030 (1959). Sasaki, M., and Makino, S., *Texas Rep. Biol. and Med.*, **18**, 493 (1960).
[3] Blumel, J., *et al.*, *A.M.A. Arch. Ophth.*, **63**, 246 (1960).
[4] Hungerford, D. A., *et al.*, *Amer. J. Human Genetics*, **11**, 215 (1959).

## BIOLOGY

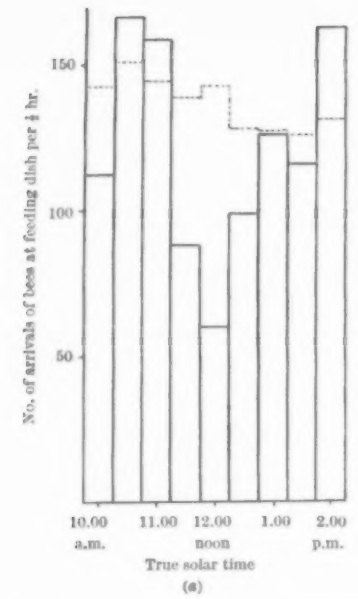
### Honeybee Communication when the Sun is Close to the Zenith

The work of von Frisch[1] and others has shown the ability of honeybees to communicate the direction of a food source by indicating the angle between the azimuths (compass direction) of the source of food and the Sun. In northern or southern latitudes, the Sun is always low enough in the sky for its azimuth to be clearly determined by the bees; but in the tropics the Sun at one or two seasons of the year passes through the zenith (that is, directly overhead), or very close to the zenith, at midday. What effect does this have on honeybee communication?

Using facilities provided by the Zoology Department of the University College of the West Indies (lat. 18° N.), experiments to answer this question were carried out in August 1959. Bees were trained to visit a feeding dish about 200 yd. from their hive. These trained bees were marked and allowed to fly back and forth between hive and dish throughout the day. Any unmarked bees that arrived at the dish were killed. The times of arrival at the dish of marked and unmarked bees were recorded.

The combined results of six days observations (August 1, 2, 3, 10, 11, 12) are shown in Fig. 1*a*. On these days the Sun at noon was always less than 3° from the zenith. These results show a pronounced fall around midday in the frequency of arrival of unmarked bees.

The combined results of observations on August 17, 18 and 19 are shown in Fig. 1*b*. On these days the noon zenith distance of the Sun was 4·5–5·0°. There



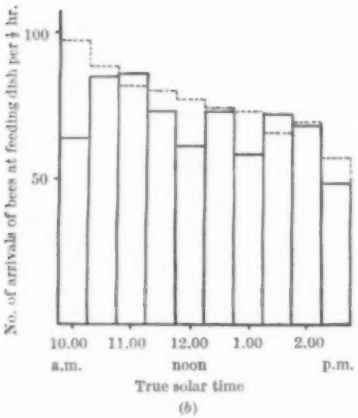




Fig. 1. Frequency of arrival of bees at different times of day. Continuous lines indicate unmarked bees. Broken lines indicate number of visits, divided by 2, of marked (trained) bees. Combined results of days (*a*) when Sun at noon less than 3° from zenith; (*b*) when Sun at noon 4·5–5·0° from zenith

is no suggestion here of a midday fall in frequency of arrival of unmarked bees.

Bad flying conditions around midday could of course account for the fall in numbers of unmarked bees shown in Fig. 1*a*. But detailed weather records failed to provide evidence for such bad conditions. In any event the number of visits of marked bees does not decline at midday. Most other possible explanations, such as a daily rhythm of hive activity, or a daily rhythm in dancing behaviour of the foragers, are ruled out by the steady arrival of unmarked bees throughout the day shown in Fig. 1*b*.

The evidence, therefore, seems strong that honeybee communication is hindered at small zenith distances of the Sun.

Fig. 2 shows the frequency of arrival of unmarked bees calculated for different zenith distances of the

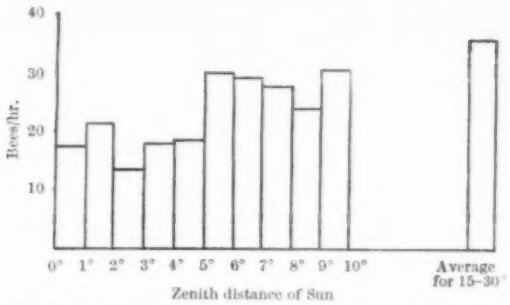



Fig. 2. Frequency of arrival of bees at different zenith distances of the Sun. Calculated from combined results of August 1, 2, 3, 10, 11, 12, 17, 18 and 19

Sun. For zenith distances of less than 5° the frequency was about half that at large zenith distances. Rather surprisingly, bees were still arriving steadily even when the zenith distance was less than 1°. Control experiments have ruled out the possibility that the bees arriving at small zenith distances are scout bees, and have made it very unlikely that they are bees delayed as a result of inaccurate information[2]. There seem to remain two possible explanations. Either the perception by some of the bees of the relative positions of Sun and zenith is extraordinarily acute, so that they are still able to determine accurately the azimuth of the Sun when its zenith distance is less than one or two degrees; or some method of communication is involved which is independent of the position of the Sun. Experiments are being carried out at present to examine these possibilities.

D. A. T. New
F. R. Burrowes
A. J. Edgar

Department of Zoology,
University College of the West Indies,
Kingston 7, Jamaica.

[1] Frisch, K. v., "The Dancing Bees" (Methuen, London, 1954).
[2] Lindauer, M., *Naturwiss.*, **44**, 1 (1957).

## Morphogenetic Effects of Lipoic Acid on Amphibian Embryos

We have recently[1,2] studied the effects of mercaptoethanol ($HS\text{-}CH_2 - CH_2OH$) and its oxidized counterpart, dithiodiglycol, on morphogenesis in a number of different systems (amphibian eggs, regenerating tadpoles and planarians, fragments of *Acetabularia*); it was always found that mercaptoethanol inhibits morphogenesis, while dithiodiglycol has no effect or is even slightly stimulatory.

It has been recently reported by Henderson and Eakin[3] that lipoic acid (5 μgm./ml.) inhibits regeneration of the head in planarians: it therefore has the same effect as mercaptoethanol in this material. It has been suggested by Henderson and Eakin[3] that lipoic acid might act by modifying the thiol-disulphide equilibrium. It was therefore decided to compare the effects of lipoic acid and mercaptoethanol on amphibian eggs, in order to find out whether, as in planarians, the two substances act in the same way.

It was found that lipoic acid (5 μgm./ml.) and mercaptoethanol at low concentrations (*M*/300–*M*/1,000), contrary to this expectation, act in completely opposite manner on *Rana temporaria* and

# Choose your

## *Cellulosic Ion-Exchangers*

# from these

# Whatman trial packets

| | |
|---|---|
| Pack 1 | CELLULOSIC ION-EXCHANGE PAPERS<br>2 sheets 9" x 11" of each grade |
| Pack 2 | CELLULOSIC ION-EXCHANGE POWDERS<br>15 g of each grade |
| Pack 3 | CELLULOSIC ION-EXCHANGE FLOCS<br>15 g of each grade |

The technique of ion-exchange using modified cellulose materials is attracting many new applications, many new users. To simplify your task of choosing which of the grades of Whatman flocs, powders or papers is best suited to your immediate needs, three trial packets of materials have been prepared. Each contains a good selection of the various cation and anion exchangers including cellulose phosphate, carboxylated cellulose, aminoethyl cellulose, DEAE-cellulose and Ectoelacellulose. Each is available at a reasonable price. A General Information leaflet describing the range of Whatman modified cellulose ion-exchangers is also available from

H. REEVE ANGEL & CO LTD
Gt. Britain 9 Bridewell Place London EC4
U.S.A. 9 Bridewell Place Clifton New Jersey

Sole Agents for

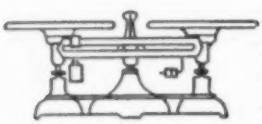
WHATMAN MATERIALS

Manufactured by W & R Balston Ltd

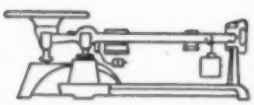
Model No.
0–CG 311
CENT-O-GRAM
Triple Beam Balance
Capacity 311 g, 0.01 g sensitivity.
£16 16s. 0d.

OHAUS

**Double and triple beam sliding weight balances**



Model No. 0–1550–S
2 kg capacity, 0.1 g sensitivity. £10 12s. 0d.



Model No. 0–750–S
2610 g capacity, 0.1 g sensitivity. £9 18s. 0d.

Here they are, available for the first time in the U.K. — the world-famous OHAUS balances, made by one of the U.S.A.'s largest balance manufacturers and justly renowned for their long life, ease of operation, and ***outstanding value for money***. OHAUS balances have a host of brilliant technical features that put them in a class by themselves. And there's a wide range of models to choose from. Write to-day for our fully illustrated leaflet.

*The best at any price*

SHANDON

**SHANDON SCIENTIFIC COMPANY LTD.**
**6 Cromwell Place, London, S.W.7 Tel. KNI 1131**



# FROM STOCK

We can supply the following life histories from stock—each is mounted in a glazed-top box

- *Large white butterfly*
- *Tortoiseshell butterfly*
- *Wasp*
- *Silk worm*
- *House Fly*
- *Bee*
- *Cockroach*
- *Stag Beetle (dissection labelled)*
- *British butterflies (20 specimens labelled)*
- *British beetles (30 specimens labelled)*
- *Pieris brassicae imagoes*

Also numerous Zoological and Botanical class demonstration mounts—list upon application

**T. GERRARD**
AND COMPANY LIMITED

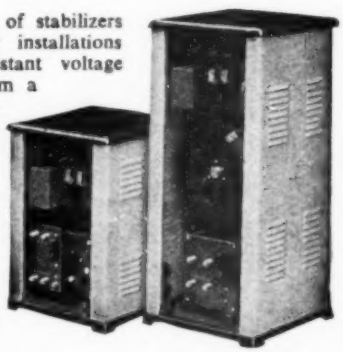
46–48 PENTONVILLE ROAD, LONDON, N.1
*Telephone: Terminus* 8006/7



ZENITH
(REGD. TRADE-MARK)

*Automatic*
**VOLTAGE REGULATORS**
*with Electronic Control*

A large range of stabilizers is available for installations requiring a constant voltage within ±1% from a supply fluctuating up to ±10% or −15% to +5%. Single- and three-phase models from 7 to 25 kVA per phase are detailed in our catalogue, which will be sent on request.



**The ZENITH ELECTRIC CO. Ltd.**
ZENITH WORKS, VILLIERS RD., WILLESDEN GREEN
LONDON, N.W.2
*Phone:* WILlesden 6581-5 *Grams:* Voltaohm, Norphone, London
MANUFACTURERS OF ELECTRICAL EQUIPMENT
INCLUDING RADIO AND TELEVISION COMPONENTS

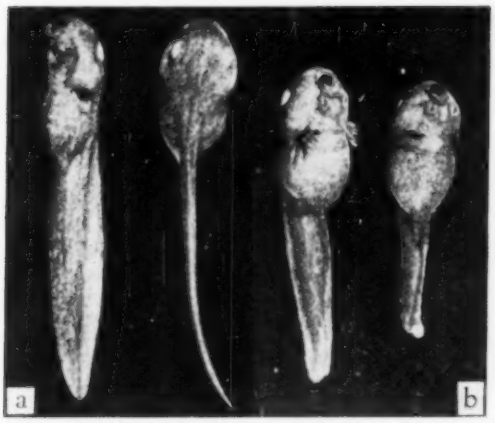



Fig. 1. (*a*) Control tadpoles of *Rana temporaria*; (*b*) embryos of *Rana temporaria* after treatment with lipoic acid (5 μgm./ml.) during 3 days

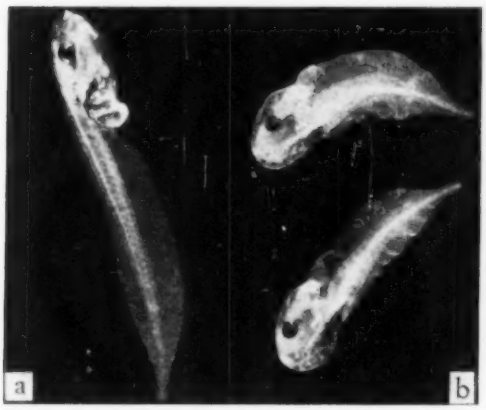



Fig. 2. (*a*) Control tadpole of *Xenopus laevis*; (*b*) embryos of *Xenopus laevis* treated during 5 days with lipoic acid (5 μgm./ml.)

*Xenopus laevis* embryos (gastrulæ or neurulæ): there is no delay in development, no inhibition of morphogenetic movements, and no microcephaly when these embryonic stages are treated with lipoic acid. On the other hand, this substance produces a marked inhibition of tail elongation, whereas the head and the size of the fin are essentially normal. This effect, which seems to be fairly specific of lipoid acid, is found in the frog (Fig. 1) as well as in *Xenopus* embryos (Fig. 2).

Extensive measurements of the length of the tail with an ocular micrometer showed that the tail undergoes a 25 per cent reduction in *Rana* and a 35 per cent reduction in *Xenopus* in tadpoles treated with lipoic acid.

In *Pleurodeles*, the effects of lipoic acid are very different; but, again, they are quite distinct from those observed in the case of mercaptoethanol. In this case, lipoic acid is so active in producing cell dissociation that concentrations as low as 0·3 μgm./ml. are still toxic. At still lower concentrations of lipoic acid, no consistent effect on the size of the tail can be detected. But another effect is visible, namely, an increase in pigmentation. Again, this effect is exactly the opposite to that observed for mercaptoethanol. The latter produces albinism and, in the case of *Xenopus*, the appearance of tadpoles with blue eyes and chromatophores[2]. This inhibition of pigmentation by mercaptoethanol is probably due, as shown by Roston[4], to the combination of thiols with an oxidation product of dioxyphenylalanine during pigment formation under the action of tyrosinase.

Since dithiodiglycol at low concentrations (*M*/10,000–*M*/100,000) exerts effects which are exactly the opposite to those of mercaptoethanol[1,2], it is obvious that it must act like lipoic acid; in fact, it has been repeatedly found that dithiodiglycol produces tadpoles with large heads and short bodies. It also produces rapid cell dissociation and lysis in *Pleurodeles*; an increase in pigmentation can often be noticed in this species after treatment with low concentrations of dithiodiglycol. However, tail reduction is rather exceptional in embryos treated with dithiodiglycol; it is thus possible that lipoic acid exerts a specific effect possibly related to its coenzyme activities, in the case of this morphogenetic process.

Finally, preliminary experiments have been made on the effects of lipoic acid (5 μgm./ml.) on regeneration in anucleate fragments of *Acetabularia*: a slight inhibition of cap formation, but much smaller than in the case of mercaptoethanol or cysteine, has been observed.

The present results, taken together with those of Henderson and Eakin[3], show that lipoic acid acts, according to the cell system under study, like mercaptoethanol or dithiodiglycol. This finding is in agreement with the view expressed by Henderson and Eakin that lipoic acid might play an important part in shifting or maintaining the intracellular thiol-disulphide equilibrium. Biochemical work is obviously required in order to test this hypothesis.

J. Brachet

Laboratoire de Morphologie animale,
Faculté des Sciences,
Université libre de Bruxelles.

[1] Brachet, J., and Delange-Cornil, M., "Developmental Biology", **1**, 79 (1959).
[2] Brachet, J., *J. Exp. Zool.*, **142**, 115 (1960).
[3] Henderson, R. F., and Eakin, R. E., *J. Exp. Zool.*, **141**, 175 (1959).
[4] Roston, S., *J. Biol. Chem.*, **235**, 1002 (1960).

## Localization of the Cells of Origin of the Ventral Spino-Cerebellar Tract

The location of the cells of origin of the ventral spino-cerebellar tract has never been determined conclusively by anatomical investigations[1]. We have now systematically searched for these cells in the lumbar segments of the cat spinal cord. Cells were identified as ventral spino-cerebellar tract neurones if they were monosynaptically excited by Golgi tendon organ (I*b*) afferents and antidromically activated on stimulation of fibres in the dissected spinal half (at *Th* 13 or *L*1), contralateral to the nerve supplying I*b* excitation[2]. The position of cells encountered was derived from the co-ordinates shown by the stereotactic instrument used for insertion of the microelectrode, and histologically controlled. Fig. 1 shows the position of the 39 ventral spino-cerebellar tract neurones (five experiments) from which successful intra-cellular recordings were obtained. All these cells were activated from ipsilateral nerves and antidromically invaded from

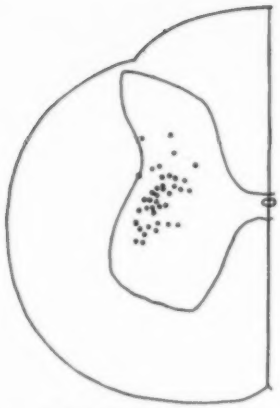


Fig. 1. Position of 39 intracellularly recorded ventral spino-cerebellar tract neurones in lumbar segments four to five

the contralateral side. Almost all units activated from the hamstring nerve were found in the upper part of the $L_5$ or lower part of the $L_4$ segment.

The present investigation has demonstrated that the ventral spino-cerebellar tract cells constitute a column of cells in the lateral part of the intermediate zone and dorso-lateral part of the ventral horn. Some cells also occur in the adjacent part of the dorsal horn. Clearly the ventral spino-cerebellar tract cells are to be distinguished from the border cells described by Cooper and Sherrington[3]. The location is, however, similar to that described by Sprague[4] for certain cells with contralaterally ascending axons, though many ventral spino-cerebellar tract cells are found more dorsally.

J. I. Hubbard
O. Oscarsson

Department of Physiology,
John Curtin School of Medical Research,
Australian National University,
Canberra.

[1] Jansen, J., and Brodal, A., "Das Kleinhirn", "Handbuch der Mikroskopischen Anatomie des Menschen" (Springer-Verlag, Berlin, 1958).
[2] Oscarsson, O., *Acta Physiol. Scand.*, **38**, 145 (1956); **40**, 222 (1957); **42**, Supp. 146, 1 (1957).
[3] Cooper, S., and Sherrington, C. S., *Brain*, **63**, 123 (1940).
[4] Sprague, J. M., *J. Neurophysiol.*, **16**, 464 (1953).

## A Chitin Medium for Isolation, Growth and Maintenance of Actinomycetes

Several different media have been suggested for isolation of Actinomycetes from soil[1]. Most of these contain carbon and nitrogen sources which are utilized by bacteria and moulds as well as by Actinomycetes, and therefore are not selective for the latter. Bacteriostatic and fungistatic chemicals such as phenol[2] and sodium propionate[3] have been incorporated into isolation media to suppress growth of bacteria and moulds and thus favour Actinomycetes. But such amendments at permissible concentrations frequently allow growth of contaminants and at higher levels may also suppress Actinomycetes. The report by Jeuniaux[4] that the polysaccharide chitin is widely utilized by members of the genus *Streptomyces* was confirmed in our laboratory in tests showing that all of 38 isolates of *Streptomyces* spp. utilized chitin as the sole carbon and nitrogen source, when supplied in an agar medium. In preliminary work, soil suspensions plated on this medium gave a predominance of Actinomycete colonies and very few bacterial and fungal colonies. These results suggested that a medium with chitin as the sole carbon and nitrogen source might be selective for isolation of Actinomycetes.

The medium used was similar to that of Reynolds[5] and consisted of colloidal chitin, 2·5 gm. (dry weight); dipotassium hydrogen phosphate, 0·7 gm.; potassium dihydrogen phosphate, 0·3 gm.; crystalline magnesium sulphate, 0·5 gm.; crystalline ferrous sulphate, 0·01 gm.; zinc sulphate, 0·001 gm.; agar, 20 gm. The *p*H of the medium was 7·0. Colloidal chitin was prepared by treating crude chitin alternately with *N* sodium hydroxide and *N* hydrochloric acid several times, then with ethyl alcohol until foreign matter was removed. This purified chitin was dissolved in cold concentrated hydrochloric acid, filtered through glass wool, precipitated in distilled water, and alternately sedimented and washed until neutral. Chitin-mineral agar was poured into Petri dishes over a 10-ml. base layer of water agar. A diluted soil suspension was applied to the chitin-mineral agar layer in either of two ways: (*a*) by mixing 0·2 ml. of soil suspension with 9·8 ml. of melted, cooled (42° C.) chitin-mineral agar before pouring; or (*b*) by spraying[6] 0·2 ml. of soil suspension on 10 ml. of the hardened medium in Petri dishes. Plates were incubated at 28° C. for 8 days.

Results in Table 1 show that Actinomycetes developed abundantly on chitin-mineral agar whereas bacteria and moulds were suppressed. Conspicuous zones cleared of chitin surrounded most of the Actinomycete colonies. By contrast, glucose-asparagine agar, egg albumin agar, and Czapek's agar, three commonly used media[1] which contain non-selective carbon sources, gave fewer Actinomycete colonies, more bacteria than Actinomycetes, and numerous moulds. At a lower dilution of soil ($10^{-4}$), the selectivity of chitin-mineral agar was still more evident. Conventional media were overgrown with bacteria and moulds which obliterated the Actinomycete colonies, whereas on chitin-mineral agar numerous Actinomycete colonies predominated. These results were verified using different soils.

Table 1. Number of Actinomycete, Bacterial and Mould Colonies Isolated when 0·2 ml. of a Soil Suspension ($10^{-4}$ Dilution) was Sprayed on Various Agar Media

| Medium | Average (5 plates) colonies per plate | | |
|---|---|---|---|
| | Actinomycetes | Bacteria | Moulds |
| Chitin-mineral | 30 | 0·4 | 0·2 |
| Glucose-asparagine | 8 | 14 | 5 |
| Egg albumin | 19 | 35 | 14 |
| Czapek's | 14 | 36 | 9 |

*Streptomyces lavendulae* and two unidentified isolates of *Streptomyces* gave more growth when cultured in chitin-mineral liquid medium (6 gm. chitin per litre) than in glucose-asparagine, egg albumin, or Czapek's broths. Chitin-mineral agar slants also supported excellent growth and sporulation of Actinomycetes.

Thus, chitin-mineral media were excellent substrates for isolation and estimation of total numbers of Actinomycetes from soil, and for growth and maintenance of cultures as well.

We gratefully acknowledge financial support given by the Horace H. Rackham Research Endowment Fund.

YAMUNA LINGAPPA
JOHN L. LOCKWOOD
Department of Botany and Plant Pathology,
Michigan State University,
East Lansing, Michigan.

[1] Waksman, S. A., "The Actinomycetes" (Chronica Botanica, Waltham, Mass., 1950).
[2] Lawrence, C. H., *Canad. J. Bot.*, **34**, 44 (1956).
[3] Crook, P., Carpenter, C. C., and Klens, P. F., *Soil Sci.*, **112**, 565 (1950).
[4] Jeuniaux, C., *C.R. Soc. Biol.*, **149**, 1307 (1955).
[5] Reynolds, D. M., *J. Gen. Microbiol.*, **11**, 150 (1954).
[6] Lockwood, J. L., *Phytopath.*, **47**, 151 (1957).

## Injury by Soaking of *Populus alba* Seeds

AIR-DRIED seeds of *Populus alba*, stored in closed vessels at + 5° C., are injured when submerged in distilled or tap water (see Table 1).

Table 1

| Duration of soaking in distilled water | Germinated Normally (per cent) | Germinated Abnormally (per cent) | Not germinated (per cent) |
|---|---|---|---|
| 0 (Control) | 64·9 ± 1·95 | 11·8 ± 0·92 | 23·4 ± 1·90 |
| 15 min. | 26·2 ± 0·50 | 40·2 ± 2·41 | 34·2 ± 2·41 |
| 35 min. | 27·0 ± 1·20 | 40·0 ± 0·53 | 33·7 ± 1·62 |
| 60 min. | 24·0 ± 0·63 | 45·9 ± 1·45 | 30·0 ± 1·33 |

The soaking medium was suddenly removed by suction on a Nutsch filter so that the seed-coats became almost dry. Any excess moisture of the germinating medium (filter-paper in Petri dishes) was carefully avoided. Seedlings having well-developed hypocotyl hairs showing regular growth and geotropic responses were considered as normal. (Unlike other seeds, the germination of *Populus* (and *Salix*) seeds begins with the extension of the hypocotyl, which shows negative geotropism. Soon around the end of the hypocotyl there appear 'hypocotyl hairs', very like the ordinary root hairs of other plants. These attach the plant very firmly to the substrate and play a great part in the geotropic stretching upright of the seedling. The first normal root emerges only later from the middle of the hypocotyl end. Though germination is very rapid, definitive counting was carried out on the third day after sowing, in order to recognize abnormal seedlings without doubt. Errors are indicated according to the formula :

$$\sigma = \pm \sqrt{\frac{S(x - \bar{x})^2}{n(n-1)}}$$

where $x$ denotes the results of singular germination experiments, $\bar{x}$ their average, $n$ the number of parallel experiments (in our case, four). Because of the small number of experiments, differences exceeding $\pm 3\sigma$ should be taken as criteria of significance.

As can be seen, soaking for 15, 35 or 60 min. equally increases the percentage of abnormal seedlings, while the decrease in germinating power is slightly significant.

Two types of abnormalities were found. Most of the abnormal seedlings show poor development of the hypocotyl hairs, absence of firm attachment to the substrate and imperfect geotropism, that is, they are leaning. On touching, they easily overturn. A few of the abnormal plants germinate inversely, that is, the cotyledons appear first. The elongation of these plants is much reduced; geotropism is completely lacking. Unfortunately, it is not possible to state quantitatively the precise proportions of these abnormalities to one another.

Table 2 provides evidence that the injuries result immediately when the seeds come into contact with water. This conclusion is not affected by the apparently poor biological value of the seeds.

Table 2

| Duration of soaking in water | Germinated Normally (per cent) | Germinated Abnormally (per cent) | Not germinated (per cent) |
|---|---|---|---|
| 0 (Control) | 57·9 ± 2·20 | 14·7 ± 0·65 | 27·3 ± 1·81 |
| 1 min. | 25·9 ± 2·32 | 43·6 ± 0·91 | 30·5 ± 2·59 |
| 30 min. | 25·0 ± 1·00 | 41·4 ± 2·78 | 33·6 ± 2·10 |

It is certain from Table 2 that anaerobiosis cannot be the cause of this striking injury. This view is confirmed by the observation that aeration in the course of soaking or previous saturation of the water with oxygen neither prevents nor increases the injury, in contrast to the experiments of Barton[1] with beans, where the presence of oxygen was very harmful.

The injury is restricted by treatments decreasing the diffusion pressure deficit of the seeds. For example, it is entirely or partially prevented by presoaking the seeds in a 2-*M* solution of sucrose for ½ hr., and then washing it out with distilled or tap water. Moreover, the damage depends largely on the humidity of the seed, as was shown also in Yamamoto's experiments with beans[2]. At a water content of 8 per cent (on dry weight basis) the damage is very severe, but it is also evident, though slight, with seeds containing 12·6 per cent of water.

The latter facts as well as the rapidity of the effect support the view that the injury is of mechanical nature, according to Iljin's theory[3] on damage due to desiccation and rehydration : the sudden distension of the cell membrane tears the protoplasm incapable of quick swelling. This interpretation is made more convincing by the observation of Sitnikova[4] that in rapidly deteriorating seeds of Salicaceae protoplasm and membrane are connected permanently by means of plasmodesms, while in other seeds a separation takes place. This is probably in connexion with the prompt germination of most *Populus* and *Salix* species; the hypocotyl hairs most susceptible to soaking injury show a particularly high growth-rate.

The practical significance of these findings is not yet clear. I suppose that soaking injury may play a certain part in the deterioration of *Populus* seeds both in Nature and forestry, particularly if propagation is by sowing stored dry seeds. In practice, it is probably important that such damage occurs

Table 3

| | Water content (dry wt. basis) (per cent) | Germinated Normally (per cent) | Germinated Abnormally (per cent) | Not germinated (per cent) |
|---|---|---|---|---|
| Control (sown on filter-paper without aeration) | 8·2 | 46·7 ± 1·2 | 25·0 ± 0·9 | 28·2 ± 0·5 |
| Aerated with humid air for 4 hr. before sowing | 14·3 | 64·9 ± 2·1 | 15·5 ± 0·5 | 19·5 ± 1·3 |

even if dry seeds are germinated on moderately moist filter paper. Aeration with humid air can 'restore' the viability of the seeds, that is, it can prevent soaking injury (Table 3)

L. Pólya

Botanical Institute,
L. Kossuth University,
Debrecen, Hungary.

[1] Barton, L. V., *Contrib. Boyce Thompson Inst.*, **16**, 55 (1950).
[2] Yamamoto, M., *Bull. Yamagata Univ.*, **4**, 361 (1958).
[3] Iljin, W. S., "Ann. Rev. Plant Physiol.", **8**, 257 (1957).
[4] Sitnikova, O. A., *Doklady Akad. Nauk S.S.S.R.*, **70**, 719 (1950).

## High Polyploidy in a New Zealand *Poa*

The basic chromosome number of *Poa* is 7. Of the New Zealand species so far examined, the majority are tetraploid ($4x = 28$) and one species is 12-ploid ($12x = 84$). A much higher number has now been found in plants of *Poa litorosa* Cheesem., collected in the Auckland Islands. Preparations of mitosis show

Fig. 1. *Poa litorosa*. Somatic metaphase showing 265 chromosomes (colchicine-2*BD*-Feulgen squash of root tip. × 1,500)

263–265 chromosomes (Fig. 1) and the species is therefore approximately 38-ploid. So far as we are aware, this is the highest chromosome number yet recorded in the Gramineae or in the Monocotyledons as a whole. Studies of meiosis and of the breeding system have yet to be undertaken.

J. B. Hair
E. J. Beuzenberg

Botany Division,
Department of Scientific and Industrial Research,
Christchurch,
New Zealand.

## BACTERIOLOGY

## Absence of the Glucose Effect on the Frequency of Lysogenization in *Salmonella typhimurium*

When a sensitive bacterial cell is exposed to a temperate bacteriophage it may undergo lysis, become lysogenized, or remain uninfected. The relative frequency with which these responses occur depends on the genetic structure of the phage and the conditions of the infection. The outcome may be influenced by temperature[1], multiplicity of infection[2], and the addition of various chemicals[3,4]. In a recent paper[5], it was reported that glucose added to a nutrient agar medium affected a 100 per cent lysogenic response with *Salmonella typhimurium* strain *LT2* ($C^+dg^s$)[6] and phage *PLT22*, while a glucose diauxie-resistant variant of this strain ($C^+dgr^{-1}$)[6] was found to be immune to this apparent glucose effect. These conclusions were based on observations of 'turbid' or 'less turbid' plaques as the criteria for lysogenization or lysis, respectively, of the initially infected cell. Recent attempts to duplicate these experiments were not successful, nor could any glucose effect on the frequency of lysogenization be detected using a more direct and reliable method developed by Luria and Fraser (ref. 4). (We wish to thank E. Bertani for details of the method and the indicator strain.)

This latter method involves plating cells infected with phage *PLT22* on *EMB* galactose medium in a soft agar layer with a galactose non-fermenting (*Gal*$^-$) indicator strain of *LT2*. The infected cells that undergo lysis form plaques in 18 hr., infected cells that are lysogenized form dark colonies surrounded by clear halos in 48 hr., and uninfected cells form dark colonies without halos in 48 hr.

The maintenance of strains, *Salmonella typhimurium LT2* ($C^+dg^s$), the glucose-resistant variant ($C^+dgr^{-1}$), and the *Gal*$^-$ variant indicator (which was also methionine-negative and histidine-negative), and the production and maintenance of phage were as previously described[6].

In the first two experiments the infection procedure was essentially as described by Bertani[4]. An aerated overnight culture of strain *LT2* ($C^+dg^s$), grown in nutrient broth, was diluted into fresh nutrient broth and aerated at 37° C. to about $5 \times 10^7$ cells/ml. The

Table 1. Frequency of Lysogenization with Glucose present during the Early Phase of the Latent Period

| Media during first 10 min. of latent period | Lytic centres* | Lysogenic cells* | Uninfected cells* | Frequency of lysogenization (per cent) |
|---|---|---|---|---|
| Nutrient broth | 35 | 34 | 36 | 49 |
| Nutrient broth plus 0·2 per cent glucose | 51 | 38 | 27 | 43 |
| Nutrient broth plus 2·0 per cent glucose | 50 | 41 | 34 | 45 |

* Figures represent average of three plates (0·1 ml. per plate)

Table 2. Frequency of Lysogenization with Glucose present during Absorption and during the Early Phase of the Latent Period

| Media during adsorption and first 10 min. of latent period | Lytic centres* | Lysogenic cells* | Uninfected cells* | Frequency of lysogenization (per cent) |
|---|---|---|---|---|
| Nutrient broth | 30 | 40 | 30 | 57 |
| Nutrient broth plus 0·2 per cent glucose | 45 | 33 | 20 | 44 |

* Figures represent average of three plates (0·1 ml. per plate).

Table 3. Frequency of Lysogenization with Glucose Present during Adsorption and during the Entire Latent Period

| Media during adsorption and entire latent period | No. of tubes plated | Average No. of cells per tube | Total lytic centres | Total lysogenic cells | Total uninfected cells | Frequency of lysogenization (per cent) |
|---|---|---|---|---|---|---|
| Nutrient broth | 30 | 2·5 | 25 | 26 | 24 | 51 |
| Nutrient broth | 30 | 2·0 | 20 | 16 | 24 | 44 |
| Nutrient broth plus 1·0 per cent glucose | 30 | 1·7 | 19 | 14 | 17 | 42 |
| Nutrient broth plus 1·0 per cent glucose | 30 | 1·7 | 22 | 16 | 15 | 42 |

cells were centrifuged, washed in buffered saline, recentrifuged, and re-suspended in buffered saline to about $2·3 \times 10^8$ cells/ml. Phage *PLT22* was then added at a multiplicity of 1 and adsorption was allowed to take place for 10 min. at 37° C. in either non-nutrient media or nutrient media, with or without glucose as indicated. The infected culture was then diluted $10^{-3}$ into nutrient broth or nutrient broth plus glucose, and aerated at 37° C. for 10 min. At this time they were diluted again into homologous media to about $1 \times 10^3$ cells/ml., and plated in triplicate on *EMB* galactose plates. Plating was done before the first bursts, which occurred about 35–40 min. after infection. Assays for free phage showed that after 10 min. more than 95 per cent of the phage had been adsorbed to the bacteria.

When cells of *LT2* were infected with phage *PLT22*, either in non-nutrient media or in nutrient broth, and afterwards incubated in nutrient broth, about 50 per cent of the cells became lysogenic. When the infected culture ($C^+dg^s$) was exposed to 0·2 per cent or 2·0 per cent glucose for 10 min. after the 10 min. adsorption in non-nutrient media without glucose, no increase was observed in the frequency of lysogenization (Table 1). In a similar experiment the cells were infected as above, except that adsorption was allowed to take place in either nutrient broth or nutrient broth plus 2·0 per cent glucose. As before, glucose did not increase the frequency of lysogenization (Table 2).

The following experiment was performed to determine the frequency of lysogenization in cells exposed to glucose during adsorption and for the entire latent period. Log phase cultures ($C^+dg^s$) with about $1 \times 10^8$ cells/ml. were infected in nutrient broth or in nutrient broth plus 1·0 per cent glucose with phage at a multiplicity of 1 and adsorption allowed to take place for 10 min. with aeration at 37° C. The cultures were then diluted to about 15–20 cells/ml. and 0·1 ml. samples were distributed to 30 small test-tubes and kept in a 37° C. water-bath for the entire latent period. (The latent period in nutrient broth plus 1·0 per cent glucose was found in a single-step growth experiment[7] to end in 70 min.) The dilution was made in order to prevent re-infection from early bursts, since the cells were not plated until they had been incubated for 70 min., and also to allow the detection of haloed colonies in the presence of plaques. The contents of the tubes were then plated with the *Gal*⁻ indicator strain on *EMB* galactose plates as previously described. Tubes were scored according to which of the following appeared on the indicator plate: plaques (lytic response), dark colonies with halos (lysogenic response), or dark colonies without halos (sensitive response). In this experiment as well, there was no increase in the frequency of lysogenization due to the presence of glucose (Table 3).

Glucose has been shown to inhibit inducible enzymes concerned 'primarily with catabolism' by somehow augmenting repression of enzyme formation in the presence of the inducer[8]. The absence of the glucose effect on the decision between the lytic and lysogenic response by temperate phage *PLT22* indicates that such inducible enzyme formation is probably not a factor in phage development under the conditions employed in these experiments. However, since glucose has no apparent effect on the synthesis of enzymes concerned with biosynthetic processes, enzymes the syntheses of which are no doubt controlled by repressor effects[9,10], the lack of effect of glucose on the frequency of lysogenization should not be interpreted to mean that the protein synthesis required for the lytic response[4] is not under repressor control.

This investigation was supported in part by a contract from the Office of Naval Research and the University of Pittsburgh, and by research grants from the National Science Foundation and the National Institute of Allergy and Infectious Diseases, United States Public Health Service.

Patricia Hoffee
Roger Weinberg
Ellis Englesberg

Department of Biological Sciences,
University of Pittsburgh,
Pittsburgh 13, Pennsylvania.

[1] Bertani, G., and Nice, S., *J. Bact.*, **67**, 202 (1954).
[2] Boyd, J. S. K., *J. Pathol. Bacteriol.*, **63**, 445 (1951).
[3] Lwoff, A., Kaplan, A., and Ritz, E., *Ann. Inst. Pasteur*, **86**, 127 (1954).
[4] Bertani, L. E., *Virology*, **4**, 53 (1957).
[5] Entner, E., and Englesberg, E., *Nature*, **182**, 1808 (1958).
[6] Englesberg, E., *Proc. U.S. Nat. Acad. Sci.*, **45**, 1494 (1959).
[7] Adams, M. H., "Methods in Medical Research", **2**, 1 (1950).
[8] Neidhardt, F. C., and Magasanik, B., *J. Bact.*, **73**, 253 (1957).
[9] Vogel, H., "Chemical Basis of Development" (Johns Hopkins Press, Baltimore, 1958).
[10] Gorini, L., and Maas, W., "Chemical Basis of Development" (Johns Hopkins Press, Baltimore, 1958).

## Isolation and Some Properties of the Phages of *B. cereus* NRRL 569

So far not enough is known about the isolation and virulent phages of *B. cereus*. Kellenberger[1] studied the morphology of the temperate phages of a lysogenic *cereus* strain. McCloy's phages isolated from the lysogenic *B. cereus W* strain[2] showed anthrax specificity. The phages of Pollock's *B. cereus* 569 strain was not known until recently[3].

Isolation of the phages of *B. cereus* 569 was attempted from five samples of soil, in each case successfully. The selective enrichment was performed as follows. The vegetative cells of the streptomycin-resistant *B. cereus* 569 were added to the samples of soil suspended in *YP* (ref. 4) liquid media with 25 γ/ml. streptomycin. This culture was incubated for 4 hr. with vigorous shaking. Streptomycin suppressed the growth of other contaminating bacteria. The enriched phage suspension was propagated further by the usual methods.

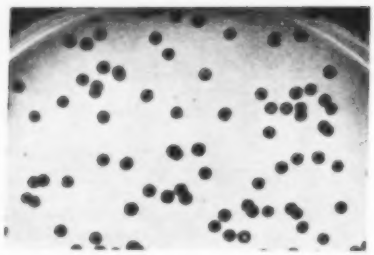


Fig. 1. Large, clear plaques of the virulent phages of *B. cereus* 569

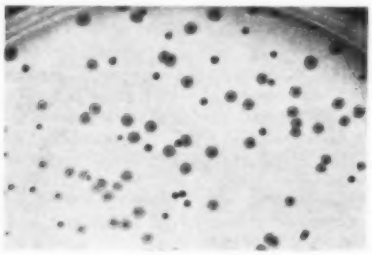


Fig. 2. Irregular clear and target-like plaques of the virulent phages of *B. cereus* 569

The propagation of the phages of *B. cereus* 569 was successful only in the *YP* (ref. 4) media. The common meat extract and Pollock's widely used media[5] were not useful for this purpose. However, with these media after being completed with $Ca^{2+}$ ($M/600$) or $Mn^{2+}$, our phages caused the lysis of the cells of *B. cereus* 569.

On the basis of plaque morphology, our phages could be separated into three different groups: (1) clear; (2) target-like; (3) turbid plaques. According to the shape and form of the plaques we succeeded in differentiating some types in each group. The turbid plaques did not give a pure line in the subcultures; the clear and target-like mutants appeared in 10 per cent.

The above-mentioned basic types are represented in Figs. 1 and 2.

The results of the host-range experiments may be summarized as follows. The isolated phages are species specific. They do not lyse anthrax and other Gram-positive bacilli (*megaterium*, *subtilis*) and cocci. The results of the investigations on many different *cereus* strains show that a group of the *cereus* bacilli is not sensitive to the phages isolated on the strain 569. The strains did not lyse nor did they absorb the phages the autolysate of which[6] produced precipitation with the anthrax polysaccharide antibody. The *B. cereus* strains the autolysate of which did not precipitate the above-mentioned antibody were sensitive to phage. On the basis of the phage sensitivity the group of the *cereus* bacteria, considered as a uniform one, may be divided into two groups: (1) sensitive to the phages of *B. cereus* 569; (2) resistant to them.

There is an interesting correlation between the phage sensitivity and structure of the cell wall. The results of earlier experiments[6] showed that the *cereus* cell wall polysaccharide which precipitates the anthrax antibody consists of galactose and glucosamine; the non-precipitating one is made up of glucose and glucosamine with another unknown hexosamine. The present experiments suggest that the isolated phages affect those *cereus* bacilli the cell-wall structure of which agrees with those of *B. cereus* 569, showing that the polysaccharide of the cell wall consists of glucose, glucosamine and another hexosamine.

Further detailed characterization of our phages and the other experiments will be published elsewhere.

J. Földes
Katalin Merétey
István Varga

Institute for Microbiology,
University of Szeged,
Hungary.

[1] Kellenberger, E., and Kellenberger, G., *Schweiz. Z. Path. Bact.*, **15**, 225 (1952).
[2] McCloy, E. W., *J. Hyg.* (Camb.), **49**, 114 (1951).
[3] Kogut, M., Pollock, M. R., and Tridgell, E. J., *Biochem. J.*, **62**, 391 (1956).
[4] Ivanovics, G., and Alföldi, L., *Acta Microbiol. Hung.*, **2**, 275 (1955).
[5] Pollock, M. R., *Brit. J. Exp. Path.*, **31**, 739 (1950).
[6] Ivanovics, G., and Földes, J., *Acta Microbiol. Hung.*, **5**, 89 (1958).

## GENETICS

### Diurnal Temperature Fluctuation and Genetic Variance in *Drosophila* Populations

Four populations of *Drosophila pseudo-obscura* were started from a common founder stock in November 1956, by Dr. L. Levine and me. Since that time, two of them, *K* 1 and *K* 2, have been maintained under conditions of temperature which, while slightly differing from year to year, have always been constant diurnally. Concurrently, the populations *V* 1 and *V* 2 have been kept in diurnally fluctuating conditions with again slight difference of mean from year to year, but always: (1) with the same mean temperature as the *K* populations and (2) undergoing a regular 10° C. oscillation of temperature during each period of 24 hr. A more detailed account of this type of environment will be found in a recent publication[1]. All populations were initially polymorphic for the two gene-arrangements Arrowhead and Chiricahua ($q_0 = 0{\cdot}5$), of the third chromosome, and all populations are now largely, if not completely, monomorphic[2]. The changes in the polymorphic system which appear to be similar in both *K* and *V* populations will be discussed elsewhere (Beardmore, J. A., and Levine, L., in preparation).

Additive genetic variance in each of the four populations was estimated in the following way. Virgin flies were collected and mated assortatively for the number of chæta on the fifth sternite. Two samples of five flies of each sex were drawn from each culture and the chæta on the fifth sternite of each fly were counted. These counts permitted the regression for chæta number of offspring on mid-parent to be calculated for each sex in each population. The slope of the best-fitting regression for the *V* populations ($b = 0{\cdot}342$) is considerably steeper than that calculated for the *K* populations ($b = 0{\cdot}215$) and the significance of this difference closely approaches the 1 per cent level. Table 1 gives the analysis of variance.

The estimates of the regression coefficients are also estimates of $h^2$, the heritability of the character and indirectly, therefore, of the additive genetic variance ($\sigma_g^2$) of the populations for this character since $h^2 = \sigma^2_g/\sigma^2_p$. The variance of parental chæta number

Table 1. Analysis of Variance of Regression of Fifth Sternite Cheta Number of Offspring on Mid-parent

| Source | Mean square | d.f. | $t$ | $P$ |
|---|---|---|---|---|
| Differences between means | 1·63 | 7 | | |
| Overall regression | 121·60 | 1 | 11·17 | very small |
| Differences between regression slopes | | | | |
| (i) between $K$ and $V$ | 6·48 | 1 | 2·574 | $\simeq 0·01$ |
| (ii) within $K$ and within $V$ | 1·01 | 6 | | |
| Residual | 0·978 | 624 | | |
| | | 639 | | |

($\sigma^2_P$) in the $K$ populations is not significantly different from that of the $V$ populations ($F = 1·09$, $P > 0·2$). The ratio of the heritabilities of $K$ and $V$ populations may, therefore, fairly be taken to represent the ratio of the additive genetic variance present in the populations.

Thoday[3,4] has considered the way in which living organisms may accommodate themselves to environmental fluctuation. His thesis is that long-term oscillations of the environment will be met by genetic flexibility of populations. Such variation is thought of as having a period several or many times the generation length of the organism. Oscillations of a short-term nature (or less than the generation time of the organism) will be accommodated by developmental flexibility. The results reported here show that a regular environmental fluctuation with a period of oscillation equal to about 5 per cent of the generation time of the organism is highly effective in promoting the maintenance of additive genetic variance by populations.

It is true that what applies to genetic variance for bristle number may not apply to other characters, and it is also true that there may be reasons peculiar to *Drosophila* which render a result of this kind less surprising than it would be in some other organisms. Nevertheless, it is quite clear that the greater genetic variance in the $V$ populations is a direct result of the diurnal environmental variation. Two conclusions follow: (1) that the greater developmental flexibility[3] or homeostasis[5] shown by the $V$ populations for which we have additional evidence (Beardmore, J. A., and Levine, L., in preparation) may be dependent on greater heterozygosity; (2) the probability of evolutionary survival of $V$-type populations is greater than that of $K$-type populations.

J. A. Beardmore

Department of Genetics,
University of Sheffield.

[1] Beardmore, J. A., *Heredity*, **14**, 411 (1960).
[2] Levine, L., and Beardmore, J., Proc. Tenth Int. Cong. Genet., **2**, 166 (1958).
[3] Thoday, J. M., Symp. Soc. Exp. Biol., **7**, 96 (1958).
[4] Thoday, J. M., *Nature*, **178**, 833 (1956).
[5] Lerner, I. M., "Genetic Homeostasis" (Oliver and Boyd, 1953).

## FOREST PRODUCTS

### A Method of obtaining Uniform Distribution of Wood Preservatives in Toxicity Test Blocks

The standard method[1] of measuring the toxicity of wood preservatives consists of exposing small wood blocks, containing a range of loadings of the preservative, to attack by a specific wood-destroying fungus or insect and noting the loading required to inhibit attack. The blocks are prepared by impregnating them completely with different strength solutions of the preservative in an appropriate volatile solvent which is afterwards allowed to evaporate off. The average concentration of preservative substance left in each block is obtained from the weight of solution absorbed.

Some time ago we showed that during evaporation of the solvent the preservative tends to concentrate near the surface so that its final distribution in the block is uneven[2]. This happens with all types of preservative substances, whether in aqueous or organic solvent solution, and probably the only exceptions are certain water-borne formulations which are designed to react and become insoluble soon after impregnation. The outward movement of solutions during the drying of porous media and the resultant migration of the solute to the surface are quite well known, and have been observed with a number of other materials such as paper, textiles and soil.

Because of this uneven distribution the concentration of preservative to which the test organism is exposed is not precisely known, and this introduces some uncertainty about the accuracy of the toxic limits found. This has been recognized for some time[3,4], but no practicable method of ensuring a more even distribution has so far been available.

Recently we have found that a comparatively uniform distribution of various types of preservative can be obtained by cooling the blocks below the

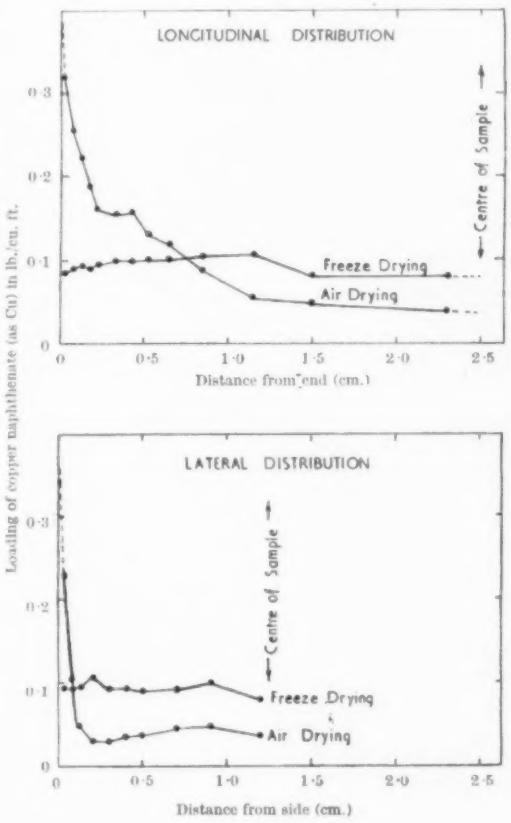



Fig. 1

freezing point of the solution directly after impregnation and subliming off the solvent under vacuum.

Fig. 1 shows the distribution in a standard-size beech block 5 × 2·5 × 1·5 cm., impregnated with a 5 per cent solution of copper naphthenate in benzene, after removal of the solvent by this method, compared with that in a similarly impregnated block dried under atmospheric conditions in the normal way.

Work on this method is still in progress, including its use in the preparation of uniformly loaded samples of the larger size used in field service tests on preservatives, for which purpose this investigation was initially undertaken, and a more detailed report will be published later.

D. N. R. Smith
R. Cockcroft

Forest Products Research Laboratory,
Princes Risborough,
Aylesbury,
Buckinghamshire.

[1] British Standards Institution, *B.S.* 838 (1939); American Society for Testing Materials, *D* 1413-56*T* (1956); Deutscher Normenausschuss, *DIN*-52 623 (1949).
[2] Cockcroft, R., *Wood*, **22**, 331 (1957).
[3] Becker, G., *Holz als Roh- und Werkstoff*, **10**, 341 (1952).
[4] Bletchly, J. D., and Taylor, J. M., Trans. Eleventh Int. Congr. Ent. Vienna (1960).

## SOIL SCIENCE

### Soil Phosphate Solubility

The inorganic phosphate content of agricultural soils is very low (about 0·02 per cent phosphorus), and attempts to determine the nature of the phosphate compounds are beset with many difficulties. X-ray and optical methods cannot be used without first concentrating the phosphate fractions, and the process of concentration generally brings about changes of phosphate form. Methods based on chemical extractants effect a more or less complete redistribution of the soil phosphate compounds during the actual extraction and, in any event, do not act specifically on single phosphate components. Recent approaches to the problems have used solubility methods, in which attempts have been made to relate soil phosphate solubility of intact soil to the solubilities of known pure phosphate compounds. Based on experimental figures for the solubility products of pure phosphates, criteria have been proposed for assessing the existence of basic calcium phosphates, and iron and aluminium phosphates in soils[1]. However, the application of these criteria to experimental determinations of soil phosphate solubility[2] has not been wholly successful[3]. Thus, while the results for some soils obey the relationships for pure compounds, others do not[3], and the proposition that these can be attributed to substances of intermediate composition is not wholly satisfactory.

In the case of basic calcium phosphates, which are generally assumed to be the main phosphate forms in non-acid soils, the solubility relationships are conveniently described in terms of the 'phosphate potentials' and 'lime potentials' of aqueous solutions in equilibrium with the solid phosphates. The potentials are defined by the equations:

$$\text{Phosphate potential} = \tfrac{1}{3}pCa + pH_2PO_4$$
$$\text{Lime potential} = pH - \tfrac{1}{2}pCa$$
where $pX = -\log_{10}$ (activity of the ion $X$)

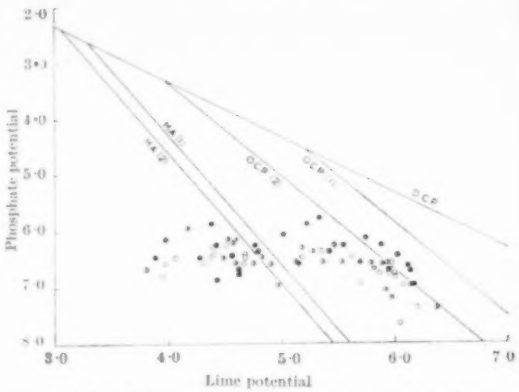



Fig. 1. Plot of phosphate and lime potentials of soils in relation to those of pure calcium phosphates. ●, Field application of 1,000 lb. phosphate ($P_2O_5$) per acre; ◑, of 500 lb. per acre; ○, of 0 lb. per acre. *D.C.P.*, dicalcium phosphate; *O.C.P.*, octocalcium phosphate from supersaturation (1), from undersaturation (2); *H.A.*, hydroxyapatite from supersaturation (1), from undersaturation (2)

For a pure calcium phosphate there is a linear relationship between the phosphate potential and the lime potential, the slope of which is governed by the chemical composition of the compound and the intercept of which is found from the experimentally determined solubility product. The linear relationships shown in Fig. 1 for dicalcium phosphate, hydroxyapatite and octocalcium phosphate are those used by Aslyng[2], based on the solubility products of Bjerrum[4]. The pairs of lines for hydroxyapatite and octocalcium phosphate are based on the solubility products determined by approaching equilibrium from undersaturation and supersaturation. If, then, one of these compounds exists in a soil, the experimentally determined phosphate and lime potentials of the soil should fall on the line for that particular compound.

To test this, the phosphate and lime potentials of soils enriched in the field with 0, 500, 1,000 lb. phosphate ($P_2O_5$) per acre as superphosphate at twenty-three sites in Britain were measured by a method similar to that described by Aslyng[2]. The soils, at soil/solution ratios of 1 : 10, 1 : 5, 2 : 5, and 4 : 5, were shaken for 16 hr. with 0·01 *M* calcium chloride solution. Each soil/solution ratio was replicated three times. The *p*H values of the suspensions were measured with a glass electrode, and, after centrifuging, the phosphate concentrations of the extracts were determined by the method of Lucena-Conde and Prat[5]. The activities of the $Ca^{++}$ and $H_2PO_4^-$ ions were calculated from the analytical figures using the known dissociation constants of phosphoric acid[2] and the first approximation to the Debye-Hückel theory. The potentials for the soil/solution ratio of 2 : 5 were calculated and plotted in Fig. 1.

Although some of the points fall near the lines for the pure compounds, the overall distribution suggests either that no definite forms of calcium phosphate can be inferred to exist in soils or that the apparent solubility relationships are being influenced by other factors. That the latter is likely is seen from the fact that all soils of low *p*H (low lime potential) have solubilities lower than that of hydroxyapatite, whereas soils of high *p*H have solubilities greater than that of hydroxyapatite. This is shown more strikingly by

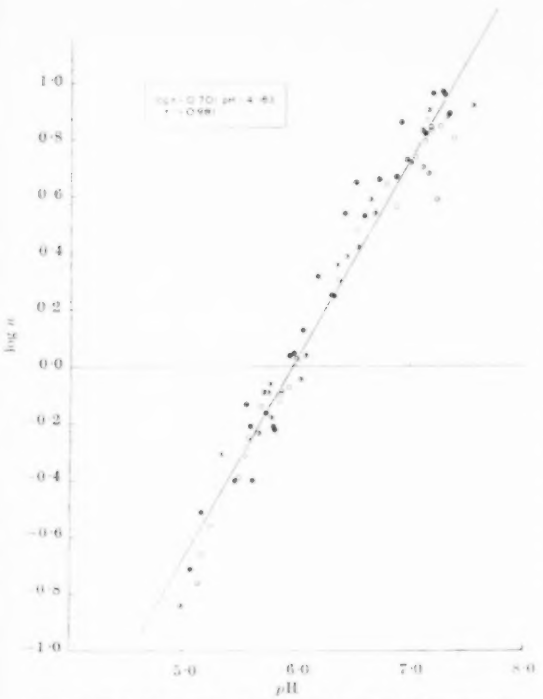



Fig. 2. Plot of logarithm of saturation index of hydroxyapatite for the soils as a function of soil *p*H. Symbols as for Fig. 1

calculating the apparent ionic product ($I$) of hydroxyapatite in the soil suspensions and relating this to the true solubility product ($L$) in pure systems. A 'saturation index' $n$ can be defined (Bjerrum, quoted by Schmidt-Nielsen[6]) as :

$$n = (I/L)^{1/9}$$
$$\text{or } \log n = (pL - pI)/9$$

The factor 1/9 appears because the solubility product of hydroxyapatite, $Ca_5(PO_4)_3OH$, is a product of nine ion activities. Values of log $n$ for the soil systems are plotted as a function of *p*H in Fig. 2. There is a consistent linear relationship with the regression equation :

$$\log n = 0{\cdot}701\ p\text{H} - 4{\cdot}183$$

and a correlation coefficient of 0·981 ($P = 0{\cdot}001$).

All soils with *p*H values above 6·0 have a phosphate solubility greater than that of hydroxyapatite, and, since hydroxyapatite is stable in this *p*H range, it should theoretically be precipitated. Why it does not has yet to be elucidated, but the results for soils resemble closely an effect observed by Greenwald[7] and Ericsson[8] for pure hydroxyapatite in the presence of calcium carbonate and for dental apatite which always contains a little calcium carbonate. These authors found that, in absence of carbonate ions, the solubility of hydroxyapatite obeyed the solubility product principle but that, in presence of carbonate ions, the principle was apparently disobeyed. Ericsson found that, in the presence of carbonate ions, the saturation index $n$ varied with *p*H according to the equation :

$$\log n = 0{\cdot}44\ p\text{H} - 2{\cdot}23$$

Greenwald attributed the increase of solubility in the presence of carbonate ions at high *p*H to the formation of complex ions in solution, but it is difficult on this basis to account for the decrease in solubility found by Ericsson at low *p*H. Ericsson's regression equation differs from that found for soils of which carbonate ions are also normal constituents. Other anions, such as silicate, present in soils could have an effect on apatite solubility similar to that of carbonate, and this may account for the difference in the two regression equations. Nevertheless, that similar relationships seem to hold is both interesting and important.

S. Larsen
M. N. Court

Department of Soil Science,
Levington Research Station,
Levington,
Ipswich.

[1] Clark, J. S., and Peech, M., *Soil Sci. Soc. Amer., Proc.*, **19**, 171 (1955). Lindsay, W. L., and Moreno, E. C., *ibid.*, **24**, 177 (1960).
[2] Aslyng, H. C., Royal Veterinary and Agricultural College, Copenhagen, Yearbook (1954).
[3] Wild, A., Trans. Fifth Int. Cong. Soil Sci., **2**, 500 (1954).
[4] Bjerrum, N., Damsgaard-Sørensen, P., and Tovborg Jensen, A., Beretn. 19, skand. naturforskarmötet i Helsingfors, 344 (1936).
[5] Lucena-Conde, F., and Prat, L., *Anal. Chim. Acta*, **16**, 473 (1957).
[6] Schmidt-Nielsen, B., *Acta Odont. Scand.*, **7**, Supp. 2 (1946).
[7] Greenwald, I., *J. Biol. Chem.*, **143**, 703, 711 (1942); **161**, 697 (1945).
[8] Ericsson, Y., *Acta Odont. Scand.*, **8**, Supp. 3 (1949).

## Direct Methods of Estimation in the Spectrographic Analysis of Cobalt in Soil Concentrates

The relationship which forms the basis of the internal standard method of spectrographic analysis may be written :

$$\log I_T/I_S = n_T \log C_T + \log a_T/a_S C_S^{n_S}$$

where $I_T, I_S$ are the respective intensities of the analysis and internal standard lines; $C_T, C_S$ are the respective concentrations of the analysis and internal standard elements; and $a$, $n$ are constants dependent on the general conditions of excitation. In its application to the determination of trace constituents in biological concentrates[1], the internal standard, which is iron, varies in content, and the calibration involves three steps : (*a*) obtaining plots of log $I_T/I_S$ (background-corrected) against log $C_T$ for sets of standard mixtures $K$, $L$, $M$, $N$, . . . containing increments of the internal standard element from one set to the next; (*b*) selecting one of these as the standard working curve, for example, the plot from the $M$ set; and (*c*) deriving a correction graph for the $C_S$ value of the sample. The calibration curves for cobalt, namely, log $I_T/I_S$ versus log $C_T$ (10–1,000 p.p.m.) and log $I_S/I_{S_M}$ versus log $C_S$ (2·0–50·0 per cent $Fe_2O_3$), are obtained as straight lines of unit gradient.

In soil analysis the concentration procedure adopted[2] is to precipitate the trace constituents on a carrier precipitate of aluminium and iron oxinates, which on ignition yields essentially a residue of aluminium oxide in admixture with iron oxide ($Fe_2O_3$) and the trace elements. In the treatment of an acetic acid soil extract[3], a solution of iron in hydrochloric acid (equivalent to 2·0 mgm. $Fe_2O_3$) is added prior to the concentration, since with the quantities involved, acetic acid extracts only traces of iron (*c.* 0·1–0·5 mgm., ref. 3), although occasionally

amounts up to the order of 1·4 mgm. (equivalent to 2·0 mgm. $Fe_2O_3$) may be extracted. The final computation of results therefore requires (i) photometric evaluation of the sample spectrum for log $I_T/I_S$, (ii) analysis of the concentrate for $C_S$, (iii) correction of log $I_T/I_S$ for the $C_S$ value of the sample, (iv) determination of $C_T$ for the corrected log $I_T/I_S$ value via the standard working curve, and (v) evaluation of the concentration in the original material on dividing $C_T$ by the appropriate factor.

A modification of the above procedure involves adding to the residue, after weighing ($w_1$ mgm.) but prior to mixing, 30 mgm. purified $Fe_2O_3$. The whole is then mixed in an agate mortar and proceeded with in the usual manner. The percentage internal standard may be estimated directly as $100 \times \left[\frac{32}{w_1 + 30}\right]$, that is, $100 \times 32/w$, where $w$ is weight of final concentrate. The error contained in this assumption may be computed as ['residual' soil $Fe_2O_3$ (say, 2·0 mgm.) + error in concentrating and analysing[4] 4·0 mgm. $Fe_2O_3$]. Since the error of a normal iron determination has been found to be 6·5 per cent ($P = 0·95$), the above error at the most is [2·0 + 0·26 ($P = 0·95$)] mgm. = 2·26 mgm. $Fe_2O_3$, which reckoned on 32 mgm. is of the order of 7 per cent. This figure compares favourably with the normal analytical error, and small differences can be ignored when field-sampling errors are taken into account[5]. Further, from the nature of the calibration curves[1,6], we may write for values of $C_T \leqslant 1{,}000$ p.p.m.:

$$\log C_T = \log(C_t/C_S)_M + \log C_S + \log I_T/I_S$$

where $C_t$ is the value of $C_T$ when log $I_T/I_S = 0$. If for log $C_S$ we substitute $\log[100 \times 32/w]$ and subtract from it the log concentration factor = $\log[2 \times 10^4/w]$ (for 20-gm. aliquots of soil), we derive an expression for the $C_T$ value in the soil, namely:

$$\log C_{T(\text{soil})} = \log (C_t/C_S)_M + \log \frac{32 \times 10^2/w}{2 \times 10^4/w} +$$

$$\log I_T/I_S = \log 0·16(C_t/C_S)_M + \log I_T/I_S$$

or

$$\log C_{T(\text{soil})} = \log k + \log I_T/I_S$$

where $k$ is a constant determined by the calibration and experimental arrangement.

Regarding the proposed modification: (i) it neither interferes with the method of analysis nor does it introduce extra work, apart from the addition of $Fe_2O_3$; (ii) it renders unnecessary the analysis of internal standard content; since these analyses are usually performed in batches of six, each batch requiring about 2 hr. for complete assay, there is a substantial saving in operational time; (iii) it does not increase unduly the final weight of concentrate which is normally about 40–60 mgm.; and (iv) it avoids graphical calculation, thereby permitting concentrations for acetic acid-soluble cobalt to be computed directly from the photometric evaluation in the ranges 0·04–3·50 p.p.m. ('normal' 40 mgm. concentrate) and 0·03–3·00 p.p.m. ('normal' 60 mgm. concentrate). Since most extractable cobalt contents fall well within the above limits, the scheme may be applied with advantage in the routine analysis of available cobalt in soils: its general application would depend on (*a*) the amounts of acetic acid-soluble iron in the run of samples being analysed, and (*b*) the magnitude of $w_1$ and the subsequent dilution with $Fe_2O_3$ to within the limits imposed by the straight-line portion of the correction graph[1].

A. B. Calder

Rutherford College of Technology,
Newcastle upon Tyne.

[1] Scott, R. O., *J. Soc. Chem. Indust.*, **65**, 291 (1946).
[2] Scott, R. O., and Mitchell, R. L., *J. Soc. Chem. Indust.*, **62**, 4 (1943).
[3] Mitchell, R. L., "The Spectrographic Analysis of Soils, Plants and Related Materials", Comm. Bur. Soil Sci. Tech. Comm. 44 (1948).
[4] Scott, R. O., *Analyst*, **66**, 142 (1941).
[5] Calder, A. B., and Voss, R. C., Consultative Committee for Development of Spectrographic Work, Bull. 1 (1957).
[6] Calder, A. B., *Spectrochim. Acta*, **16**, 331 (1960).

## ARCHÆOLOGY

### An Extinct Giant Pangolin and Associated Mammals from Niah Cave, Sarawak

Examination of the mammalian remains excavated from the west mouth of Niah Cave, Sarawak[1], in 1954–58 down to a depth of 72 in., which corresponds to a carbon-14 date of about 32,000 years B.P. (ref. 2), established a fauna containing only the lowland evergreen rain forest species of modern south-east Asia[3]; of those identified, only the Malay tapir[4] and the tiger (an unerupted canine from Neolithic levels (*E/G*1, 6–12 in.)) are to-day unknown from the wild in Borneo.

Extension of the dig to lower levels has now produced three bones attributable to *Manis palaeojavanica* Dubois—an extinct giant pangolin formerly known only from Middle Pleistocene deposits in Java—from depths at Niah (*H*/17, 104–110 in.) corresponding to carbon-14 dates of about 42–47,000 years B.P. (ref. 5). Besides man (represented by skeletal remains as well as artefacts of stone and bone) the associated mammalian fauna includes only extant species. Represented are: pig (*Sus* cf. *barbatus*), orang utan (*Pongo pygmaeus*), monkeys (certainly *Presbytis* species, others indeterminate), a wild cat (*Felis* cf. *bengalensis*), a large bovine (*Bubalus* c.q. *Bibos* species), the larger mouse-deer (*Tragulus napu*), a number of rats (including *Rattus* cf. *sabanus*, cf. *mulleri* and cf. *rattus*), a shrew (*Crocidura* species), and several bats (identified by the Earl of Cranbrook) (including *Rousettus* cf. *amplexicaudatus*, *Hipposideros* cf. *diadema*[a], cf. *galeritus*[a], and two indeterminate species of intermediate size, *Chaerephon* species, *Cheiromeles* cf. *torquatus*[a] and *Myotis* species[a]), as well as the common recent Malaysian pangolin (*Manis javanica*); the last has never before been found in the fossil or sub-fossil state. The Niah finds prove the co-existence of the two species of *Manis* in the Upper Pleistocene of Borneo.

Fuller reports will be published in forthcoming issues of the *Sarawak Museum Journal*.

Tom Harrisson

Sarawak Museum, Kuching.

D. A. Hooijer

Rijksmuseum van Natuurlijke Historie,
Leyden.

Medway

Department of Anatomy,
University of Birmingham. Oct. 18.

[1] See Harrisson, T., *Man*, **59**, 1 (1959), and *Sarawak Mus. J.*, Nos. 12–14 (New Series), for earlier progress reports of this excavation.
[2] Harrisson, T., *Sarawak Mus. J.*, **9**, 137 (1959).
[3] Medway, Lord, *Sarawak Mus. J.*, **8**, 627 (1958).
[4] Medway, Lord, *Sarawak Mus. J.*, **9**, 146 (1959).
[5] By extrapolation from figures given by Harrisson, *l.c.*, ref. (2).
[6] Still found in the cave: Medway, Lord, *Sarawak Mus. J.*, **8**, 667 (1958).

# FORTHCOMING EVENTS

*(Meetings marked with an asterisk * are open to the public)*

## Monday, January 16

ROYAL GEOGRAPHICAL SOCIETY (at 1 Kensington Gore, London, S.W.7), at 5 p.m.—Mr. J. E. Thorpe and others: "A University Expedition to British Honduras".

BRITISH SOCIETY FOR THE PHILOSOPHY OF SCIENCE (in the Joint Staff Common Room, University College, Gower Street, London, W.C.1), at 5.30 p.m.—Prof. K. R. Popper: "The Growth of Knowledge" (President's Address).

SOCIETY OF CHEMICAL INDUSTRY, PESTICIDES GROUP (at 14 Belgrave Square, London, S.W.1), at 5.30 p.m.—Dr. Hubert Martin: "Pesticides and the Public".

UNIVERSITY OF LONDON (in the Physiology Theatre, University College, Gower Street, London, W.C.1), at 5.30 p.m.—Prof. F. Bergel, F.R.S.: "Biochemistry and Biology of Enzymes in Cancer".*

## Monday, January 16—Friday, January 20

INSTITUTE OF PHYSICS AND THE PHYSICAL SOCIETY (at the Royal Horticultural Society's Halls, Westminster, London, S.W.1)—45th Annual Exhibition.

## Wednesday, January 18

BRITISH INSTITUTION OF RADIO ENGINEERS, COMPUTER GROUP (at University College, Gower Street, London, W.C.1), at 2–5 p.m. and 6–8 p.m.—Symposium on "Alpha Numeric Displays".

INSTITUTE OF PHYSICS AND PHYSICAL SOCIETY, ACOUSTICS GROUP (at the Royal Horticultural Society (New Hall), Vincent Square, London, S.W.1), at 2 p.m.—Symposium on "Traffic Noise". Speakers: Dr. D. W. Robinson, Mr. C. H. G. Mills and Miss S. W. Forgarty.

ROYAL SOCIETY OF ARTS (at John Adam Street, Adelphi, London, W.C.2), at 2.30 p.m.—Mr. Oliver N. Millar: "The Restoration Portrait" (Fred Cook Memorial Lecture).

INSTITUTE OF PHYSICS AND PHYSICAL SOCIETY, LOW TEMPERATURE GROUP (at 47 Belgrave Square, London, S.W.1), at 4 p.m.—Annual General Meeting. 4.30 p.m.—Dr. R. W. Hill: "The Thermodynamic Properties of Fluid Helium".

BONE AND TOOTH SOCIETY (at the Institute of Orthopædics, 234 Great Portland Street, London, W.1), at 4.30 p.m.—Symposium on "The Temporo-Mandibular Joint".

ROYAL METEOROLOGICAL SOCIETY (at 49 Cromwell Road, London, S.W.7), at 5 p.m.—Mr. J. S. A. Green: "A Problem in Baroclinic Stability"; Mr. F. Knighting: "Some Computations of the Variation of Vertical Velocity with Pressure on a Synoptic Scale".

INSTITUTION OF ELECTRICAL ENGINEERS, SUPPLY SECTION (at Savoy Place, London, W.C.2), at 5.30 p.m.—Mr. M. N. John: "A General Method of Digital Network Analysis particularly suitable for use with Low-Speed Computers"; Dr. P. P. Gupta and Prof. M. W. Humphrey Davies: "Digital Computers in Power System Analysis".

SOCIETY OF CHEMICAL INDUSTRY, CORROSION GROUP (at 14 Belgrave Square, London, S.W.1), at 6 p.m.—Mr. R. L. Samuel: "Metallic Diffusion Coatings".

ROYAL INSTITUTE OF CHEMISTRY (at King's College, Strand, London, W.C.2), at 6.30 p.m.—Prof. Sir C. N. Hinshelwood, O.M., F.R.S.: "Aspects of the Chemistry of Living Cells".

## Wednesday, January 18—Thursday, January 19

INSTITUTION OF MECHANICAL ENGINEERS (at 1 Birdcage Walk, Westminster, London, S.W.1), at 2.30 p.m. on Wednesday and 10 a.m. on Thursday—Symposium on "Pressure Vessel Research Towards Better Design".

## Thursday, January 19

NORTHAMPTON COLLEGE OF ADVANCED TECHNOLOGY (at St. John Street, London, E.C.1), at 3 p.m.—Prof. Dimitri Riabouchinsky (l'Académie des Sciences de l'Institut de France): "Some Special Problems in Fluid Mechanics".

LONDON MATHEMATICAL SOCIETY (at the Royal Astronomical Society, Burlington House, Piccadilly, London, W.1), at 5 p.m.—Dr. E. C. Zeeman: "Geometric Topology".

UNIVERSITY OF LONDON (in the Physiology Theatre, University College, Gower Street, London, W.C.1), at 5 p.m.—Dr. A. N. Michelson: "Nucleotide Anhydrides and Oligonucleotides".* (Further lecture on January 26.)

SOCIETY OF CHEMICAL INDUSTRY, ROAD AND BUILDING MATERIALS GROUP (at 14 Belgrave Square, London, S.W.1), at 6 p.m.—Mr. J. R. P. Jordan: "Problems Associated with Research on Aggregates".

PHARMACEUTICAL SOCIETY OF GREAT BRITAIN (at 17 Bloomsbury Square, London, W.C.1), at 7.30 p.m.—Mr. K. A. Lees: "Fermentation Processes in Preparing Pharmaceutical Materials".

ROYAL SOCIETY OF TROPICAL MEDICINE AND HYGIENE (at Manson House, 26 Portland Place, London, W.1), at 7.30 p.m.—Dr. T. Wilson: "Filariasis in Malaya".

SOCIETY FOR VISITING SCIENTISTS (at 5 Old Burlington Street, London, W.1), at 7.30 p.m.—Discussion Meeting on "Atmospheric Pollution". Chairman: Dr. R. Lessing, C.B.E. Speakers: Dr. S. R. Craxford, Dr. P. J. Lawther and Dr. E. A. J. Mahler.

BRITISH INSTITUTE OF RADIOLOGY (at 32 Welbeck Street, London, W.1), at 8 p.m.—Mr. P. E. Thompson Hancock, Mr. J. D. N. Nabarro and Mr. P. B. Kunkler: "Treatment of the Reticuloses by Chemotherapy and Radiotherapy".

## Friday, January 20

ASSOCIATION OF APPLIED BIOLOGISTS (in the British Museum (Natural History), Cromwell Road, London, S.W.7), at 10.40 a.m.—Symposium on "Recent Developments in Plant Nematology".

INSTITUTE OF NAVIGATION (at the Royal Geographical Society, 1 Kensington Gore, London, S.W.7), at 5.15 p.m.—Mr. A. Stratton and Mr. K. R. Honick: "Presentation of Height Information in Aircraft".

INSTITUTION OF ELECTRICAL ENGINEERS, EDUCATION DISCUSSION CIRCLE (at Savoy Place, London, W.C.2), at 6 p.m.—Discussion on "Management Studies for Junior Engineers", opened by Mr. G. S. C. Lucas.

SOCIETY OF CHEMICAL INDUSTRY, FINE CHEMICALS GROUP (at 14 Belgrave Square, London, S.W.1), at 6.30 p.m.—Dr. M. C. Whiting: "The Chemistry of some Macrocyclic Antibiotics".

ROYAL AERONAUTICAL SOCIETY (in the Lecture Theatre, 4 Hamilton Place, London, W.1), at 7 p.m.—Mr. Lorne Welch: "Gliding and Man-Powered Flight".

## Saturday, January 21

LONDON COUNTY COUNCIL (at the Horniman Museum, London Road, Forest Hill, London, S.E.23), at 3.30 p.m.—Miss R. Osborn: "High Life Among Gorillas".*

# APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

SCIENTIFIC OFFICER (with a good honours degree in chemistry or botany, preferably with some postgraduate experience) IN THE WEEDS SECTION, to work on problems associated with the absorption, mobility and persistence of herbicides in soils—The Secretary, National Vegetable Research Station, Wellesbourne, Warwick (January 28).

HEAD OF THE DEPARTMENT OF SCIENCE of the Jamaica College of Arts, Science and Technology, Kingston—The Council for Overseas Colleges, 12 Lincoln's Inn Fields, London, W.C.2 (January 31).

LECTURER (honours graduate in science) IN THE DEPARTMENT OF BUILDING SCIENCE—The Registrar, The University, Liverpool, quoting Ref. CV/N (January 31).

LECTURER IN THE HISTORY OF SCIENCE—The Secretary, The University, 38 North Bailey, Durham (January 31).

LECTURER OR ASSISTANT LECTURER IN THE DEPARTMENT OF APPLIED MATHEMATICS—The Registrar, The University, Liverpool (January 31).

RESEARCH ASSISTANT (with an honours degree in physics) IN THE DEPARTMENT OF MATHEMATICS, to continue and develop a fundamental investigation of the rheological properties of concentrated polymer solutions—The Registrar, The Manchester College of Science and Technology, Sackville Street, Manchester 1 (January 31).

SENIOR LECTURER (preferably active in magneto-fluid dynamics or plasma physics and able to initiate research in one of these fields) IN MATHEMATICS—The Secretary, Royal College of Science and Technology, George Street, Glasgow, C.1 (January 31).

LECTURER (with a degree in science, preferably in chemistry) IN THE DEPARTMENT OF EDUCATION—The Registrar (Room 22, O.R.B), The University, Reading (February 1).

CHAIR OF LOGIC—The Secretary of University Court, The University, Glasgow (February 3).

ASSISTANT, Assistant Experimental Officer grade (with a pass degree or equivalent qualification), IN THE DEPARTMENT OF POTATO GENETICS, to help in biochemical investigations in potatoes—The Secretary, John Innes Institute, Bayfordbury, Hertford, Herts (February 7).

LECTURER OR ASSISTANT LECTURER IN PURE MATHEMATICS—The Registrar, The University, Leeds 2 (February 7).

LECTURER OR ASSISTANT LECTURER IN PURE MATHEMATICS; and a LECTURER OR ASSISTANT LECTURER IN APPLIED MATHEMATICS—The Secretary and Registrar, The University, Southampton (February 10).

SENIOR LECTURER (preferably with some experience in physical anthropology and comparative anatomy) IN ANATOMY at the University of Sydney, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia and London, February 10).

LECTURER (with an honours degree in psychology and interests in experimental psychology) IN PSYCHOLOGY at the University of Canterbury, Christchurch, New Zealand—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (New Zealand and London, February 14).

SENIOR TECHNICIAN (with training in histological techniques and the preparation of teaching material) IN THE ZOOLOGY DEPARTMENT, University of Canterbury, Christchurch, New Zealand—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (New Zealand and London, February 15).

SENIOR LECTURER OR LECTURER (with special qualifications, teaching and research experience in either biogeography and climatology, or cultural (especially economic) geography) IN GEOGRAPHY at the University of Auckland, New Zealand—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (New Zealand and London, February 17).

CHAIR OF APPLIED MECHANICS tenable in the Newcastle Division of the University—The Registrar, University Office, 46 North Bailey, Durham (February 18).

CHAIR OF PHYSICS tenable in the Newcastle Division—The Registrar, University Office, 46 North Bailey, Durham (February 18).

JOHNSON AND JOHNSON RESEARCH FELLOW (with previous experience in tissue transplantation or related fields), to investigate problems of tissue transplantation—The Secretary, East Grinstead Research Trust, Queen Victoria Hospital, East Grinstead, Sussex (February 24).

CHAIR OF INORGANIC CHEMISTRY tenable in the NEWCASTLE DIVISION of the University—The Registrar, University Office, 46 North Bailey, Durham (February 25).

LECTURER or ASSISTANT LECTURER IN ELECTRONICS—The Secretary and Registrar, The University, Southampton (February 28).

DEMONSTRATOR IN INORGANIC CHEMISTRY—Dr. Lee's Professor of Chemistry, Physical Chemistry Laboratory, The University, South Parks Road, Oxford (March 1).

CHAIR OF METALLURGY within the Faculty of Engineering, University of Sydney, Australia—The Secretary Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia and London, March 15).

JUNIOR MYCOLOGIST (with a good honours degree in botany, postgraduate training in systematic mycology, a working knowledge of Latin and German, with Russian an added qualification) at the Commonwealth Mycological Institute, Kew—The Secretary, Commonwealth Agricultural Bureaux, Farnham House, Farnham Royal, Bucks (March 31).

LECTURER IN RADIATION BIOLOGY—The Secretary, Department of Biology as Applied to Medicine, Middlesex Hospital Medical School, London, W.1 (April 1).

ASSISTANT, Grade B (with an honours degree in physics, research or industrial experience in some branch of applied physics, and preferably teaching experience) IN THE DEPARTMENT OF PHYSICS—The Registrar, Bristol College of Science and Technology, Ashley Down, Bristol 7.

ASSISTANT LECTURER (graduate in chemistry, and preferably with experience in the food industry)—The Principal, National College of Food Technology, St. George's Avenue, Weybridge, Surrey.

ASSISTANT (young research worker interested in the electron microscopic structure of cells) IN THE CANCER RESEARCH UNIT—Prof. G. Causey, Department of Anatomy, Royal College of Surgeons, Lincoln's Inn Fields, London, W.C.2.

GEOLOGISTS (preferably under 35, a first- or good second-class honours degree in geology with emphasis on metamorphic and igneous rocks and/or structural geology, and preferably previous experience) in Tanganyika, for regional geological survey of metamorphic and igneous rock terrains, and preliminary investigation of mineral deposits—The Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD.114/7/06.

GEOLOGIST (with a first- or upper second-class honours degree in geology) in the Bechuanaland Protectorate, to undertake general geological surveys, including the examination of mineral deposits, water supply problems and geological mapping—The Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD.105/76/03.

OFFICER (with a degree in science, or diploma in horticulture or agriculture), to assist in field experimental work—The Secretary, National Vegetable Research Station, Wellesbourne, Warwick.

PHYSICISTS (with a second-class honours degree or equivalent in mathematics or physics, and for the more senior posts, at least three years postgraduate research experience), to join a team engaged on an experimental programme on the Fast Reactor—The Personnel Manager, U.K.A.E.A., Dounreay Experimental Reactor Establishment, Thurso, Caithness, quoting Ref. 163/34.

# REPORTS and other PUBLICATIONS

(*not included in the monthly Books Supplement*)

## Great Britain and Ireland

The Institute of Personnel Management. Annual Report, 1959–60. Pp. 27. (London: Institute of Personnel Management, 1960.) [1710

*Planning*, Vol. 26, No. 445 (17 October, 1960): The Growing Economy—Britain, Western Germany and France. Pp. 281–308. (London: Political and Economic Planning, 1960.) 3*s.* 6*d.* [1710

The Water Research Association. Fifth Annual Report, 1959–60. Pp. 24+4 plates. (Redhill: The Water Research Association, 1960.) [1710

The National Central Library. 44th Annual Report of the Executive Committee for the year ending 29 February, 1960. Pp. 20. (London: The National Central Library, 1960.) [1710

Some Aspects of Agricultural Research No. 2: a Reprint of the Articles in the Report of the Agricultural Research Council for the year 1958–59. Pp. ii+77. (London: H.M. Stationery Office, 1960.) 3*s.* 6*d.* net. [1710

Imperial College of Science and Technology (University of London). Research Report of the Royal School of Mines, 1957–1960. Pp. iii+69. (London: Imperial College of Science and Technology (University of London), 1960.) [1710

*The Quarterly Journal of the Royal Astronomical Society*, Vol. 1, No. 1 (September, 1960. Double issue.) Pp. 128. 24*s.*; 3.60 dollars. Annual subscription 40*s.*; 6 dollars. Single issues 12*s.*; 1.80 dollars. (London: Royal Astronomical Society, 1960.) [1810

Negretti and Zambra, Ltd. Publication T/446: Quecksilber/Stahl: Temperaturschreiber. Pp. 6. Instruments for Use by Indian Industries: Temperature, Pressure, Humidity, Volume, Flow. Pp. 12. (London: Negretti and Zambra, Ltd., 1960.) [1810

Royal Institute of Chemistry, London Section. Annual Report of the Committee, 1960. Pp. 9. (London: Royal Institute of Chemistry, 1960.) [1910

A Synopsis of the Work and Growth of the Commonwealth Forestry Bureau, Oxford, 1939–1959. Pp. 27. (Oxford: Commonwealth Forestry Bureau, 1960.) 2*s.* 6*d.* [1910

Institution of Metallurgists. Metallurgy: The Study and Use of Metals. (A pamphlet for Scientific Sixth Forms.) Pp. 8. (London: Institution of Metallurgists, 1960.) [2410

Department of Scientific and Industrial Research. Road Research Laboratory and Geological Survey and Museum. Sources of Road Aggregate in Great Britain. Third Edition. Pp. v+113. (London: H.M. Stationery Office, 1960.) 6*s.* net. [2410

Department of Scientific and Industrial Research: Geological Survey and Museum. British Regional Geology—London and Thames Valley. By the late Dr. R. L. Sherlock. Third edition, with some additions by Dr. R. Casey, S. C. A. Holmes and Dr. V. Wilson. Pp. iv+62+5 plates. (London: H.M. Stationery Office, 1960.) 5*s.* net. [2410

Science and Art in Leather Manufacture: an Inaugural Lecture. By Prof. A. G. Ward. Pp. i+20. (Leeds: Leeds University Press, 1960.) 2*s.* 6*d.* net. [2410

Freshwater Biological Association. Scientific Publication No. 19: A Key to the British Species of Crustacea: Malacostraca Occurring in Fresh Water, with Notes on their Ecology and Distribution. By Dr. H. B. N. Hynes, Dr. T. T. Macan and W. D. Williams. Pp. 36. (Ambleside: Freshwater Biological Association, 1960.) 3*s.* [2410

The Chemical Society. Periodicals in the Chemical Society Library. Pp. 48. (London: The Chemical Society, 1960.) [2410

## Other Countries

New Zealand. Report of the Director of Forestry for the year ended 31 March, 1960. Pp. 115. New Zealand Forest Service. Information Series No. 22: Publications of the New Zealand Forest Service for the period 1 April 1959 to 31 March 1960. Pp. 8. (Wellington: Government Printer, 1960.) [1710

Durban Museum Novitates. Vol. 6, Part 2 (1st September, 1960): Miscellaneous Taxonomic Notes on African Birds, 15, by P. A. Clancey. Pp. 13–45. (Durban: Durban Museum, 1960.) 5*s.* net. [1710

Instituto Antartico Argentino. Contribucion No. 39: Normas Tecnico-Practicas para Efectuar un Viaje en Trineo Tirado por Perros. Por Rene E. Dalinger y Emilio Ricci. Pp. 22. (Buenos Aires: Instituto Antartico Argentino, 1959.) [1710

Indian Forest Bulletin (New Series). Wood Seasoning. No. 226: Design and Operation of an Improved Type of Indirect-Heated Thermal-Circulation Furnace Kiln. By M. A. Rehman, D. P. Ghosh and M. L. Mehra. Pp. i+7+2 plates. (Delhi: Manager of Publications, 1960.) Rs. 1.30nP.; 2*s.* [1710

Sveriges Geologiska Undersökning. Ser. Aa., No. 200: Beskrivning till Kartbladet Eskilstuna. Av P. H. Lundegårdh och G. Lundqvist. Pp. 125+1 plate+map. (Stockholm: Sveriges Geologiska Undersökning, 1960.) 10 Kr. [1710

Forest Research in India, 1956–57. Part 1: The Forest Research Institute. Pp. iii+117. (Delhi: Manager of Publications, 1960.) Rs. 3.00; 5*s.* [1710

New Zealand Forest Service: Forest Research Institute. Technical Paper No. 29: Methods of Measurement and Volume Calculation for Exotic Conifers. By G. Duff. Pp. 18. (Wellington: Government Printer, 1960.) [1910

Proceedings of the California Academy of Sciences. Fourth Series. Vol. 31, No. 7 (September 30, 1960): First Records of the Echeneidid Fish *Remilegia australia* (Bennett) from California, with Meristic Data. By W. I. Follett and Lillian J. Dempster. Pp. 169–184+1 plate. (San Francisco: California Academy of Sciences, 1960.) [1910

Republic of the Sudan. Ministry of Agriculture: Forests Department. Report for the period July, 1958 to June, 1959. Pp. v+138. (Khartoum: Forests Department, Ministry of Agriculture, 1960.) [1910

Sandia Corporation. General Instructions for the Recovery of Radioactive Contaminated Equipment. Pp. 21. (Albuquerque, New Mexico: Sandia Corporation, 1960.) [1910

Massachusetts Institute of Technology. Fast Fundamental Transfer Processes in Aqueous Biomolecular Systems. Pp. iv+56. (Cambridge, Mass.: Department of Biology, Institute of Technology, 1960.) [2410

Somaliland. Annual Report of the Geological Survey Department for period April 1959–March 1960. Pp. ii+27. (Hargeisa: Stationery Office, 1960.) Shs. 2. [2410

Sandia Corporation. Reprints, Monographs and Research Colloquia—Title List. Pp. 20. (SCRB-60-2). (Albuquerque, New Mexico: Sandia Corporation, 1960.) [2410

United Nations Educational, Scientific and Cultural Organization. Centro de Cooperacion Cientifica para America Latina. Scientific Institutions and Scientists in Latin-America. Argentina (Cientificos) (E-M), IV Volumen, Fasciculo 3. Pp. i+213–452. (Montevideo: Unesco, Centro de Cooperacion Cientifica para America Latina, 1960.) [2410

Federation of Nigeria: Ministry of Mines and Power. Records of the Geological Survey of Nigeria, 1958. Pp. 40+7 plates. (Lagos: Federal Government Printer: London: Crown Agents for Oversea Governments and Administrations, 1960.) 10*s.* [2410

Commonwealth of Australia. Twelfth Annual Report of the Commonwealth Scientific and Industrial Research Organization for the year ending 30th June, 1960. Pp. ii+129. (Melbourne: Commonwealth Scientific and Industrial Research Organization, 1960.) [2410

Tea Research Institute of East Africa. Pamphlet No. 17: Proceedings of the Sixth Conference, 29th and 30th October, 1959. Pp. 72. (Kericho: Tea Research Institute of East Africa, 1960.) [2410

*Editorial and Publishing Offices of "NATURE"*
MACMILLAN & CO., LTD.,
ST. MARTIN'S STREET, LONDON, W.C.2.
Telephone Number: Whitehall 8831. Telegrams: Phusis Lesquare London

Annual subscription £8 8/–, payable in advance, postage paid to any part of the world.

*Advertisements only should be addressed to*
T. G. Scott & Son, Ltd., 1 Clement's Inn, London, W.C.2
Telephone Number: Holborn 4743

All rights reserved. Registered as a newspaper at the General Post Office

**DETERMINE THE GAS CONTENT OF HIGH PERFORMANCE METALS WITH**

WILD BARFIELD NRC*

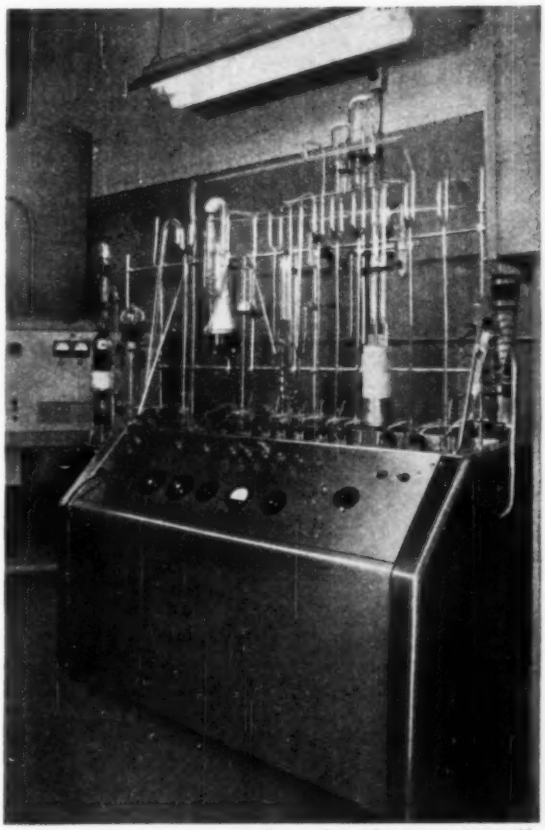
# *Vacuum Analysers*

Metallurgists have found that the physical characteristics of high performance metals and alloys are highly dependent upon their gas content. Well over 100 developmental and quality control laboratories throughout the world use NRC vacuum analysers for precise measurement of gas content.

The Model 912 Vacuum Fusion Gas Analysis Apparatus shown here is a versatile instrument for measuring the amount of oxygen, hydrogen, and nitrogen. For most metals it is accurate to within one or two parts per million.

To avoid service failure of highly stressed titanium parts through hydrogen embrittlement, routine determination of hydrogen content is required by producers and users of the metal. The Model 917 analyser measures hydrogen content ranging from a few to 500 ppm by means of hot extraction in a vacuum. The method is rapid and accurate; the unit simple to operate.

We shall be pleased to supply further details on request.



*Vacuum Fusion Gas Analyser Model 912, a self-contained unit of reliability and accuracy*

**OTHER VACUUM EQUIPMENTS**

- **Arc Furnaces**
- **Induction Furnaces**
- **Resistance Furnaces**
- **High Vacuum Diffusion Pumps**

* *is the trade-mark of the National Research Corporation, registered in the United States Patent Office.*

ELECTRIC WILD BARFIELD FURNACES

**FOR *ALL* HEAT-TREATMENT PURPOSES**

**WILD-BARFIELD ELECTRIC FURNACES LIMITED**

ELECFURN WORKS, OTTERSPOOL WAY, WATFORD BY-PASS, WATFORD, HERTS. Telephone: Watford 26091 (8 lines)

NRC6

## APPOINTMENTS VACANT

### AUSTRALIAN NATIONAL UNIVERSITY

INSTITUTE OF ADVANCED STUDIES
DEPARTMENT OF MATHEMATICS

Applications are invited for appointments in all grades in the newly established Department of Mathematics in the Research School of Physical Sciences. The Department will be concerned with research, and training in research, initially in pure mathematics; it will be headed by Dr. B. H. Neumann, F.R.S., Professor-Elect. The appointments will be made at levels appropriate to the qualifications and experience of the successful candidates. Superannuation is on the F.S.S.U. pattern. Reasonable travel expenses are paid and assistance with housing is provided.

A summary of conditions of appointment, including the types of posts available with the appropriate salaries, is available from the Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1. Applications close, in Australia and London, on February 20, 1961.

---

FEDERAL GOVERNMENT OF NIGERIA

### STORAGE ENGINEER

Required for the Stored Products Research Unit of the Ministry of Commerce and Industry. The officer appointed would probably be posted to Kano in Northern Nigeria, and will be required to undertake research on techniques of storing foodstuffs, such as the appraisal of special types of warehouses and silos, etc. The successful candidate would be required to undertake a special course in the United Kingdom before leaving for Nigeria.

Candidates must possess a B.Sc. honours degree in zoology (second-class or above). Postgraduate experience in entomology would be an advantage. Candidates should not be over 45 years of age. Both men and women may apply.

Appointment on contract for one tour of 12 to 18 months in the first instance with prospect of extension. Salary according to qualifications and experience in the scale £972 to £2,040 per annum (including inducement addition), plus gratuity of £100 to £150 per annum on satisfactory completion of service. Incremental credit will be awarded for postgraduate experience in stored products work. Outfit allowance of £60 on salaries under £1,741. Free passages for officer and wife. Children's allowances while separated. Liberal home leave on full pay. Income tax at low local rate. Quarters at low rent.

Write for application forms and further particulars within ten days of publication, stating briefly age, qualifications and experience, to the Appointments Secretary, Federal Public Service Commission, Nigeria House, 9 Northumberland Avenue, London, W.C.2, quoting E.13/4.

---

RESEARCH INSTITUTE (ANIMAL VIRUS Diseases), Pirbright, Surrey, invites applications: (1) For an appointment in the Tissue Culture Section. Applicants should have an honours degree in bacteriology or zoology and have experience of culture techniques applied to mammalian tissue. Salary in Principal Scientific Officer grade, £1,600 to £2,325 or Senior Scientific Officer grade, £1,250 to £1,590, depending on age, qualifications and experience. Superannuation under F.S.S.U. House available for married applicant. Applications to the Secretary. (2) From young graduate physicists or physical chemists for a post in the Biophysics Department. The successful candidate will be engaged upon the application of a variety of physical-chemical techniques to the study of viruses and related biological systems, and will be encouraged to work for a higher degree. Current methods of investigations include electronmicroscopy, ultracentrifugation, light scattering and X-irradiation, etc. Interest rather than experience is required at this stage. The appointment will be made according to age and experience in the Scientific Officer grade, £690 to £1,175, or Senior Scientific Officer grade, £1,250 to £1,590. Superannuation under F.S.S.U. House available for married applicant.—Applications to the Secretary.

---

# CHEMICAL TECHNOLOGY

## The United Kingdom Atomic Energy Authority

require senior staff for posts at Aldermaston.

## CHEMISTS, CHEMICAL ENGINEERS & PHYSICISTS

for fundamental and applied research on a wide variety of organic and inorganic chemical problems, e.g., Powder Technology; Gas-Solid Reactions; Fabrication Processes; High Temperature Reactions; Pilot Plant Studies; Flowsheeting; Plant and Equipment Development, Design and Specification.

## CHEMISTS and CHEMICAL ENGINEERS

are also required for Plant Manager posts, controlling manufacturing and chemical process operation, also commissioning and operation of gas purification plants.

**APPOINTMENTS WILL BE MADE TO GRADES CARRYING SALARIES UP TO £2,500 PER ANNUM.**

Candidates should have appropriate background experience. An Honours Degree or Corporate Membership of a relevant Professional Institution is essential.

SUPERANNUATION — HOUSING — HOUSE PURCHASE ASSISTANCE

Excellent working conditions and recreational facilities

APPLY TO: **The Senior Recruitment Officer, A.W.R.E., Aldermaston, Berks.**

(quoting Ref.: 2889/34).

---

THE MIDLANDS RESEARCH STATION OF THE GAS COUNCIL

# ANALYTICAL CHEMISTS

Applications are invited from analytical chemists for positions in this Research Station located at Solihull, Warwickshire, which is developing new methods of town gas production by the gasification and hydrogenation of coal and oil.

Preferred candidates will be corporate members, by examination, of the Royal Institute of Chemistry, and will be experienced in the analysis and testing of solid and liquid fuels. Duties will involve both the application of standard methods and the conduct of such analytical investigations as the work may require.

The salary will be commensurate with qualifications and experience.

*Please write fully to the Industrial Relations Officer*
**West Midlands Gas Board, 6 Augustus Road, Edgbaston, Birmingham, 15**

## AUSTRALIA

### COMMONWEALTH SCIENTIFIC AND INDUSTRIAL RESEARCH ORGANIZATION

## MICROBIAL GENETICIST

The Organization's Division of Plant Industry, Canberra, A.C.T., invites applications for the position of Microbial Geneticist from Honours graduates in Science or Agricultural Science with some years post-graduate research experience, preferably in microbial genetics.

The Division has for several years conducted extensive research into microbiological, biochemical, and genetical aspects of *Rhizobium* biology. As a member of a large team of geneticists conducting research in several fields of pure and applied genetics, the appointee is required to participate in the general programme by undertaking genetical studies of *Rhizobium*. Technical assistance and a well equipped microbial genetics laboratory are available.

Salary: Dependent on qualifications and experience within the ranges £A.1,510 to £A.2,265 per annum or £A.2,395 to £A.2,720 per annum.

Salary for a woman will be £A.180 per annum less than corresponding rates for men.

By mutual agreement, appointment may be for an indefinite period or for a fixed term of three or five years.

Promotion within C.S.I.R.O. is by merit and may ultimately go beyond the upper limit of the scale within which the original appointment is made.

Fares paid and, for a short-term contract, return fares paid. Further details of conditions, etc., supplied on application to:

Mr. E. J. Drake, Chief Scientific Liaison Officer, Australian Scientific Liaison Office, Africa House, Kingsway, London, W.C.2,

to whom applications (quoting Appointment No. 130/464) should be addressed by February 18, 1961.

## ATTRACTIVE OPPORTUNITIES

in

## Agricultural and Biological Research

with the

## Canadian Department of Agriculture

Current vacancies embrace the fields of:

- **ZOOLOGY**
- **MICROBIOLOGY**
- **CHEMISTRY**
- **FOOD TECHNOLOGY**
- **ANIMAL, PLANT AND SOIL SCIENCE**

These positions offer an opportunity to work with well-known Scientists, and the facilities provided rank with the finest in the world.

Enquiries are invited from graduate and post-graduate students in the above fields with a good academic standing, possessing aptitude for research and the ability to prepare technical reports.

Information Circular 61-10, with full details of all requirements, and application forms are available on request from the CIVIL SERVICE COMMISSION, OTTAWA, CANADA.

JOHN INNES INSTITUTE REQUIRE AN Assistant with chemical background to help in biochemical investigations in potatoes in the Department of Potato Genetics. The appointment will be in the Assistant Experimental Officer grade, and a Pass Degree or equivalent qualification is required. Salary will be in the range £520 to £745 per annum according to age and experience. Superannuation.—Applications, with the names of two referees, should be addressed to the Secretary, Bayfordbury, Hertford, not later than February 7, 1961.

FELLOWSHIPS AND ASSISTANTSHIPS for advanced degree students in the fields of metallurgy, ceramics and semiconductors. A new Materials Research Centre provides exceptional facilities for basic research and graduate studies in kinetics physical ceramics and metallurgy, imperfection studies in solids, physics of solids, thermodynamics and X-ray diffraction.—Applicants with degrees in mathematics, the physical sciences or engineering will be considered. Department of Materials Science, the Technological Institute, Evanston, Illinois.

## UNIVERSITY OF DURHAM

### THE MEDICAL SCHOOL, KING'S COLLEGE NEWCASTLE UPON TYNE AND THE UNITED NEWCASTLE UPON TYNE HOSPITALS

The Council of King's College invites applications for the post of Lecturer in Dermatological Biochemistry. The Lecturer will be appointed to the Department of Dermatology which is situated in the Teaching Hospital, Royal Victoria Infirmary, but will work under the joint direction of the Professor of Dermatology and the Head of the Biochemical Section of the Department of Pathology. He will be expected to take part in teaching, and will be required particularly to pursue research on skin physiology, cell metabolism and serum protein disturbances in immunological reactions. The successful applicant will be appointed at a suitable point on the Lecturers' Non-medical Grade (£1,050 to £1,850), according to qualifications and experience. F.S.S.U. and family allowances.

Applications (12 copies), including the names of three referees, should be submitted not later than February 11, 1961, to the Registrar and Secretary of King's College, from whom further particulars may be obtained.

## SENIOR RESEARCH OFFICER

### ELECTROLYTIC ZINC COMPANY OF AUSTRALASIA LIMITED

Applications are invited for a position as a Senior Research Officer in the Company's Research Department at Risdon, near Hobart, Tasmania. Applicants should possess a university degree in chemistry or chemical engineering; they should have obtained honours or higher degrees, and should have had some years' experience in research. The Research Department is concerned with development projects and is responsible for the solution of problems which arise in connection with the Company's various activities, which include the production of zinc, ammonium sulphate, superphosphate, sulphuric acid, etc. The duties are essentially similar to those in the Research Department of any large chemical industry. Applicants should preferably be in the age range 28 to 35 years. The commencing salary offered for the position will depend on the qualifications and experience of the successful applicant, but will be at the rate of not less than £A.2,100 per annum. In addition, a bonus based on the rate of dividends declared by the Company is paid half-yearly; for 1959 the bonus was approximately 15 per cent of salary. The appointee will be eligible to participate in the Company's Staff Provident Fund and in the Medical, Hospital and Dental Schemes run by the Company. The Company will pay fares for a successful applicant and his family (if any) to travel to Australia by sea. An unfurnished house or flat can be made available on a rental basis for a married applicant.

Applications should include details of education and experience and must include details of subjects studied at the University and the standard of passes obtained. Applications should include the names of at least three referees and should be addressed to: The General Superintendent, Electrolytic Zinc Company of Australasia Limited, G.P.O. Box 377-D, Hobart, Tasmania, Australia.

## UNIVERSITY OF MANCHESTER

### IMPERIAL CHEMICAL INDUSTRIES FELLOWSHIPS

Applications are invited for the above Research Fellowships, founded by Imperial Chemical Industries Ltd., tenable in the University and available for research in various branches of Chemistry, Chemical Engineering, Engineering, Technology, Physics and allied subjects. The value of the Fellowships will be within the range of £800 to £1,100 per annum according to qualifications and experience.

Regulations governing the award of the Fellowships may be obtained from the Registrar, the University, Manchester 13, to whom applications should be sent not later than February 14, 1961.

## UNIVERSITY OF MANCHESTER

### TURNER AND NEWALL RESEARCH FELLOWSHIPS

Applications are invited for the above Research Fellowships, founded by Messrs. Turner and Newall Ltd., tenable in the University and available for research in engineering, inorganic chemistry, physics and allied subjects. The value of the Fellowships will be within the range of £800 to £1,100 per annum according to qualifications and experience.

Regulations governing the award of the Fellowships may be obtained from the Registrar, the University, Manchester 13, to whom applications should be sent not later than February 14, 1961.

## RUTHERFORD COLLEGE OF TECHNOLOGY

NEWCASTLE UPON TYNE
DEPARTMENT OF CHEMISTRY AND METALLURGY

Applications are invited for the following full-time teaching posts, which arise from the expansion within the Department:

1. Senior Lecturer in Chemical Technology, to teach this subject to final Dip. Tech. standard, to develop this section of the Department, and to initiate and supervise students' projects. Applicants should be well qualified in Chemical Engineering or Chemical Technology, and should have had appropriate industrial and/or teaching experience. A particularly well qualified applicant could be considered for the post at Principal Lecturer grade. New laboratories are being set up and equipped, and the successful applicant will be expected to take an active part in this work.

2. Senior Lecturer in Inorganic Chemistry, to teach this subject from post-O.N.C. to final B.Sc. and Grad. R.I.C. level. Candidates must be honours graduates, and should have had industrial and/or teaching experience. The successful candidate will be responsible for the organization of the Inorganic Chemistry section of the Department. Ability to initiate or direct research or specialized knowledge of modern analytical methods would be an advantage. The Department is housed in new buildings and is well-equipped for teaching and research.

3. Lecturer in Metallurgy, to teach this subject to H.N.C., L.I.M., and A.I.M. standard. Candidates should be honours graduates, and have had appropriate teaching and/or industrial experience. Facilities for research will shortly be available and research will be encouraged.

Salary according to the Burnham (1959) Report, viz.: Senior Lecturer, £1,550 by £50 to £1,750; Lecturer, £1,370 by £35 (final £40) to £1,550.

Further particulars and forms of application (returnable within 14 days of the appearance of this advertisement) may be obtained from the Principal, Rutherford College of Technology, Northumberland Road, Newcastle upon Tyne, 1.

## LINCOLNSHIRE RADIOTHERAPY CENTRE

PHYSICS LABORATORY

Applications are invited for the post of Isotope Laboratory Technician in the Lincolnshire Radiotherapy Centre now being set up at St. George's Hospital, Lincoln. The work involved is the use of various types of isotopes both on patients for diagnostic studies and therapeutic treatment and also experimental studies. Candidates should have a good school record with passes in physics and mathematics at O or Advanced Level of the G.C.E., or O.N.C. in applied physics or Inter. B.Sc. or equivalent qualifications. Salary scale at age 21, £570 to £710 per annum.

Applications, giving details of education, qualifications and experience, together with names of two references, should be addressed to the Group Secretary, Lincoln No. 1 Hospital Management Committee, County Hospital, Lincoln, from whom further particulars can be obtained.

## SOUTH DEVON AND EAST CORNWALL HOSPITAL

AREA PATHOLOGICAL LABORATORY, GREENBANK ROAD, PLYMOUTH

Applications are invited from suitably qualified persons for the post of Non-medical Biochemist, Senior Grade, in this Laboratory.

Applications, stating age, nationality, qualifications, experience and names of three referees, to Group Secretary, 7 Nelson Gardens, Stoke, Plymouth.

## TANGANYIKA

GEOLOGISTS

Qualifications: First- or good second-class honours degree in geology with emphasis on metamorphic and igneous rocks and/or structural geology. Previous experience desirable. Age limit: Preferably under 35. Duties: Regional geological survey of metamorphic and igneous rock terrains. Preliminary investigation of mineral deposits. Terms of appointment: On contract for one or two tours of 30 to 36 months, with gratuity of 16½ per cent of emoluments after first tour, and 25 per cent for second tour. Salary according to experience in scale £1,194 to £1,863. Free passages. Generous education allowances. Quarters at rental. Generous leave. Full medical attention.

Apply to Director of Recruitment, Colonial Office, London, S.W.1, stating full name, age, qualifications and experience. Quoting BCD.105/8/03/C1.

## UNIVERSITY OF MANITOBA

DEPARTMENT OF PHYSICS

Applications are invited for positions as (1) Professor (minimum salary $12,000 per annum) (2) Associate Professor (minimum salary $9,000 per annum). Persons sought are those with high qualifications in experimental nuclear physics, preferably, though not necessarily, with cyclotron experience, to work with the 50 MeV. sector-focused cyclotron now under construction in this Department. Appointments will be to the full-time academic staff, and will involve some teaching, but emphasis will be placed on the development of the cyclotron research programme.

For further information apply to Dr. B. G. Whitmore, Head, Physics Department, University of Manitoba, Winnipeg, Manitoba, Canada.

## UNITED KINGDOM ATOMIC ENERGY AUTHORITY

## TECHNICAL ADMINISTRATION

Vacancies exist at the Dounreay Experimental Reactor Establishment, Thurso, Caithness, for University Graduates and young people with G.C.E. or the Scottish Leaving Certificate at the Higher Level.

Duties will range in a wide field of Technical Administration and will include:

1. Forward planning of deployment of effort and expenditure for the compilation of project and product costs.

2. Examining progress in relation to programme.

3. Preparation of reports.

4. Maintenance of records of experimental reactors and associated chemical plants for operating efficiency studies and costing purposes.

Salaries assessed according to qualifications and experience from £390 (at age 18) for the lower grades, and from £475 (at age 18) to £1,360 for the more senior posts.

Housing assistance schemes. Hostel accommodation available. Contributory superannuation.

Send postcard for application form to the Personnel Manager at the above address, quoting reference 150/34.

## SOMERSET RIVER BOARD

ASSISTANT IN THE FISHERIES AND POLLUTION DEPARTMENT

Applications are invited for the above appointment on salary grade A.P.T. II (£815 to £960). Applicants should have some knowledge of fresh water biology and chemistry. Duties will include inspection of sewage works and trade waste treatment plants, river surveys, and the examination of samples. It will be an advantage if the person appointed is able to drive a car, for which an allowance will be paid. The post is superannuated and subject to N.J.C. conditions.

Applications, stating age, qualifications and previous experience, must reach the undersigned by January 30, 1961.

E. L. KELTING, O.B.E., J.P., M.I.C.E., Barrister-at-law, Chief Engineer.

Somerset River Board,
The Watergate, West Quay,
Bridgwater, Somerset.

## STOKE MANDEVILLE HOSPITAL

AYLESBURY

Assistant Biochemist required in the Area Pathology Laboratory based at the above hospital. Applicants should possess first- or second-class honours degree in chemistry or biochemistry, or A.R.I.C. Whitley Council conditions of service. Salary £925 to £1,150 per annum after (for new entrants only) a probationary period. The post offers a wide variety of experience in a well-equipped and pleasant laboratory.

Applications, giving full details of qualifications, etc., together with names of two referees, to be forwarded to the Administrative Officer as soon as possible.

## UNIVERSITY COLLEGE OF THE WEST INDIES

FACULTY OF AGRICULTURE
(IMPERIAL COLLEGE OF TROPICAL AGRICULTURE)
TRINIDAD

Applications are invited for: (i) Lectureship in Agriculture from graduates in Agriculture (or equivalent), preferably with some teaching and research experience; knowledge of farm machinery and soil and water conservation desirable. Tropical experience very desirable but not essential. Duties will be instruction in tropical crop husbandry and assistance in general research work of Department. (ii) Plant Physiologist, Plant Pathologist and an Entomologist in Regional Research Centre to participate in research programme on citrus with priority on (a) premature ageing of trees, associated with pests, diseases, parasites and epiphytes; and (b) rootstock/scion relationships with reference to virus status. Appointments to be made in Lecturer or Senior Lecturer grade. Salary scales (under review): Senior Lecturer, £1,500 by £75 to £2,250 per annum; Lecturer, £1,150 by £50 to £1,450 by £75 to £1,900 per annum. Entry point determined by qualifications and experience. Child allowance. F.S.S.U. Unfurnished accommodation, if available, at rental not in excess of 10 per cent of basic salary. Up to five full passages on appointment, termination and study leave (once every three years).

Detailed applications (six copies), naming three referees, by February 28, 1961, to Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1, from whom further particulars may be obtained.

## BECHUANALAND PROTECTORATE

GEOLOGIST

Qualifications and duties: Applicants must possess a first- or upper second-class honours degree in geology and will be required to undertake general geological surveys, including the examination of mineral deposits, water supply problems and geological mapping. Age: preferably under 35. Terms of appointment: On contract for tour of two and a half years, with gratuity on satisfactory completion. Salary, according to experience, in the scale £928 to £1,848. Free passages. Quarters at rental. Generous leave. Income tax at local rates.

Apply to Director of Recruitment, Colonial Office, London, S.W.1, stating full name, age, qualifications and experience, quoting BCD.105/76/03/C1.

## CUMBERLAND EDUCATION COMMITTEE

WHITEHAVEN COLLEGE OF FURTHER EDUCATION

Principal: J. Nicholson, B.Sc., A.R.I.C., A.I.M., F.C.S., F.R.S.A., Dip.Ed.

Assistant, Grade B, required in the Department of Physics and Mathematics for May 1, 1961. Candidates should possess a good honours degree in Physics. Opportunities will be offered to a suitable candidate to assist in the development of courses in Nuclear Physics. The College is well equipped and is housed in new buildings. Extensions, including laboratories for work in radio-activity, are to be occupied in the near future. Whitehaven is within easy reach of the Lake District. Burnham salary scale, £700 to £1,150, with additions for approved qualifications and training.

Application forms (to be returned by January 27, 1961) from the Principal, College of Further Education, Flatt Walks, Whitehaven.

GORDON S. BESSEY,
Director of Education.

5 Portland Square,
Carlisle.

## UNIVERSITY OF LEEDS

DEPARTMENT OF MATHEMATICS

Applications are invited for appointment as Lecturer or Assistant Lecturer in Pure Mathematics at a salary on the scale £1,050 by £50 to £1,400 by £75 to £1,850 (efficiency bar at £1,550) a year for a Lecturer, or within the range £800 to £950 a year for an Assistant Lecturer, according to age, qualifications and experience.

Applications (three copies), stating date of birth, qualifications and experience, together with the names of three referees, should reach the Registrar, the University, Leeds, 2 (from whom further particulars may be obtained) not later than February 7, 1961; candidates overseas may apply in the first instance by cable, naming three referees, preferably in the United Kingdom.

## UNIVERSITY OF CANTERBURY
CHRISTCHURCH, NEW ZEALAND
SENIOR LECTURER IN MATHEMATICS

Applications are invited for the above-mentioned position in the Department of Mathematics. High mathematical qualifications will be required and previous experience in working with a digital computer would be an advantage. The appointee will be expected to engage in research work in the field of computer programming or in some other field of applied mathematics or to assist with work in the field of rocket trajectories already in progress in the Mathematics Department. The salary will be at the rate of £1,750 per annum, rising by annual increments to £2,000 per annum. Commencing salary in accordance with qualifications and experience. Approved fares to Christchurch will be allowed for the appointee, his wife and children. In addition actual removal expenses will be allowed within specified limits.

Further particulars and information as to the method of application should be obtained from the Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1. Applications close, in New Zealand and London, on February 28, 1961.

## UNIVERSITY OF DURHAM
COMPUTING LABORATORY
NEWCASTLE UPON TYNE

A research worker is required to study calculations performed in the shipbuilding industry and to construct programmes for an automatic computer. Applicants should be graduates and familiar with numerical methods and computers, but previous knowledge of shipbuilding is not essential. The post which is being financed by the British Shipbuilding Research Association is for three years. Salary in the range £850 by £50 to £1,050 per annum, plus F.S.S.U.

Applications, giving details of qualifications and experience and the names of two referees, should reach the Director, University Computing Laboratory, 1 Kensington Terrace, Newcastle upon Tyne 2, not later than February 4, 1961.

REGISTRAR,
University Office,
46 North Bailey,
Durham.

## UNIVERSITY COLLEGE, DUBLIN
I.C.I. RESEARCH FELLOWSHIPS

Applications are invited for I.C.I. Research Fellowships in Biochemistry, Chemistry or Physics, to which some appointments may be made during the current academic year. The appointments will date from October 1, 1961 (or earlier in the case of a selected candidate who may be available before that date) and will be for one year in the first instance; the maximum period of appointment is three years. The salary will depend upon qualifications and experience and will normally be within the range £800 to £1,100 per annum, together with family allowances.

Applicants should hold a Ph.D. or have equivalent research experience. Applications (three copies; from overseas one will suffice) should give age particulars of training, qualifications, research and other relative experience, a list of publications, an outline of the proposed field of research, and the names of two referees. Applications will be accepted up to March 7, 1961, by the undersigned, from whom a form (of which the use is optional) and other particulars may be obtained.

J. J. HOGAN,
Registrar.

## ROYAL COLLEGE OF SCIENCE AND TECHNOLOGY
GLASGOW

Applications are invited for a new Senior Lectureship in Mathematics. Preference will be given to a candidate active in magneto-fluid dynamics or plasma physics and able to initiate research in one of these fields. The salary scale is £1,975 by £75 to £2,275. Superannuation is through the F.S.S.U. and children's allowances are paid.

Applications should be lodged with the Secretary of the College, George Street, C.1 (from whom further details may be obtained), not later than January 31, 1961.

## CARDIFF HOSPITAL MANAGEMENT COMMITTEE

Senior Biochemist, suitably qualified, required at Sully Hospital (318 beds), near Penarth, Glam. Work will include co-operation with Surgical Department in investigation of biochemical problems. N.H.S. conditions and salary (£1,250 to £1,700 per annum)

Form of application from Group Secretary, 44 Cathedral Road, Cardiff.

## COMMONWEALTH AGRICULTURAL BUREAUX

The Executive Council invites applications for the post of: Assistant Director, Bureau of Animal Breeding and Genetics, King's Buildings, West Mains Road, Edinburgh 9, Scotland. Candidates should have a good science degree, preferably with some knowledge of genetics and/or statistics. They should also have a knowledge of at least two foreign languages. Salary £1,650 to £2,325 with provision for superannuation. Starting point depends on age, qualifications and experience.

Applications should be submitted by March 31, 1961, to: The Secretary, Commonwealth Agricultural Bureaux, Farnham House, Farnham Royal, Bucks, England, from whom further particulars, including passage regulations, can be obtained.

FEDERAL GOVERNMENT OF NIGERIA

## SENIOR RESEARCH OFFICERS

Required by the Federal Institute of Industrial Research of the Ministry of Commerce and Industry, near Lagos, to supervise a small research team and to plan and carry out laboratory research and development work on either food processing, fermentation processes, vegetable oils, wood extracts, and on other research for the development of Nigerian raw materials, or coal utilization, pulp and paper, ceramic pigments, general inorganic and physical chemistry, and on other research for the development of Nigerian raw materials.

Candidates must possess a first- or second-class honours degree in phyics or chemistry or equivalent professional qualification. They must also have had at least five years research or development experience in one or more of the subjects mentioned above, and have proved their ability to lead a small research team. Both men and women candidates may apply.

Appointment on contract for one tour of 12 to 18 months in the first instance with prospect of extension. Salary according to qualifications and experience in the scale £1,800 to £2,040 per annum (including inducement addition), plus gratuity of £150 per annum on satisfactory completion of service. Free passages for officers and wives. Children's allowances while separated. Liberal home leave on full pay. Income tax at low local rate. Quarters at low rent.

Write for application forms and further particulars within ten days of publication, stating briefly age, qualifications and experience, to the Appointments Secretary, Federal Public Service Commission, Nigeria House, 9 Northumberland Avenue, London, W.C.2, quoting E.12/4.

## AUSTRALIAN NATIONAL UNIVERSITY
INSTITUTE OF ADVANCED STUDIES
JOHN CURTIN SCHOOL OF MEDICAL RESEARCH

Applications are invited for appointment as Research Fellow to work in the field of neurophysiology in the Department of Physiology. The salary will be within a range, at present £A.1,437 to £A.2,152, which is under review. Appointment will be for three years, with possible extension to a maximum of five years. Superannuation is on the F.S.S.U. pattern. Reasonable travel expenses are paid, and assistance with housing is provided.

Further particulars are available from the Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1. Applications close, in Australia and London, on February 17, 1961.

## IRELAND
Of interest to graduates in
CHEMISTRY

Examiner of applications for Patents. Salary scale: £590 to £1,300 (man); £585 to £1,050 (woman). Commencing salary up to £850 (man) or £761 (woman). Age limits: 23 to 40 years, with extensions. Essential: First- or second-class honours degree (or equivalent) in chemistry and two years experience in chemistry.

Application forms, etc., from Secretary, Civil Service Commission, 45 Upper O'Connell Street, Dublin. Latest time for receiving completed application forms: 5 p.m. on January 31, 1961.

## UNIVERSITY OF HONG KONG
LECTURESHIP IN GEOGRAPHY

Applications are invited for the above-mentioned post. Applicants should possess at least a good honours degree in geography and preference will be given to candidates with experience of teaching geography in a university department. The successful applicant will be required to lecture in Historical and Human Geography up to honours degree standard and preference will be given to candidates who are also able to assist with the teaching of either Political or some aspects of the Regional Geography of Asia. In addition some assistance with the Practical Geography courses will be expected. Annual salary (superannuable) is £1,575 by £50 to £2,175 for a man or £1,200 by £40 to £1,680 for a woman. There is also an expatriation allowance of £225 a year if applicable. The equivalent of income tax in the Colony is comparatively low. First-class sea passages are provided for expatriate staff and their families on first appointment and leaves. Accommodation at reasonable rental is provided for those receiving expatriation allowance. The successful applicant will be expected to take up his/her duty as soon as possible.

Further particulars and information as to the method of application should be obtained from the Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1. Applications close, in Hong Kong and London, on February 17, 1961.

## UNIVERSITY OF NEW BRUNSWICK
FREDERICTON, N. B., CANADA
DEPARTMENT OF MATHEMATICS

Applications are invited for the post of Assistant or Associate Professor in the Department of Mathematics. Applicants should possess an honours degree in mathematics and preferably some postgraduate experience in research or teaching. Commencing salary will be according to qualifications.

Further particulars may be obtained from the Head of the Department.

## QUEEN MARY COLLEGE
(UNIVERSITY OF LONDON)

Applications are invited for the post of Lecturer in Applied Mathematics, tenable from October 1, 1961. Salary scale £1,050 by £50 to £1,400 by £75 to £1,550 (efficiency bar); by £75 to £1,850 plus London allowance of £60, F.S.S.U. participation and family allowance of £50 for each child. Initial salary according to qualifications and experience.

Application forms, obtainable from the Registrar, Queen Mary College, Mile End Road, E.1, to be returned by January 31.

## UNIVERSITY OF SYDNEY
SENIOR LECTURESHIP IN ANATOMY

Applications are invited for the above-mentioned position. Some experience in physical anthropology and comparative anatomy is desirable. The salary for a Senior Lecturer is within the range £A.2,550 by £A.95 to £A.3,000 per annum, plus cost of living adjustments and will be subject to deductions under the State Superannuation Act. The commencing salary will be fixed according to the qualifications and experience of the successful applicant. Under the Staff Members' Housing Scheme in cases approved by the University and its Bankers, married men may be assisted by loans to purchase a house.

Further particulars and information as to the method of application should be obtained from the Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1. Applications close, in Australia and London, on February 10, 1961.

## UNIVERSITY OF CANTERBURY
CHRISTCHURCH, NEW ZEALAND
LECTURER IN PSYCHOLOGY

Applications are invited for the above-mentioned post. Applicants should have an honours degree in psychology and interests in experimental psychology in particular. The salary will be at the rate of £1,250 per annum rising by annual increments of £75 to £1,700 per annum. Commencing salary will be in accordance with qualifications and experience. Approved fares to Christchurch will be allowed for an appointee, his wife and children. In addition, actual removal expenses will be allowed within specified limits.

Further particulars and information as to the method of application should be obtained from the Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1. Applications close in New Zealand and London on February 14, 1961.

# ROLLS-ROYCE

The Rolls-Royce advanced project team working on nuclear marine propulsion needs a few more individuals prepared to contribute their initiative.

There is room for

## ENGINEERS & PHYSICISTS

Don't apply unless you have a good honours degree.

Don't apply if you want a quiet life and someone to tell you what to do next.

Apply

**ROLLS-ROYCE LIMITED**

**OLD HALL, LITTLEOVER, DERBY**

## SYNTHETIC AND PHYSICAL ORGANIC CHEMISTS

ICI

**SYNTHETIC AND PHYSICAL ORGANIC CHEMISTS**

are required by

**PLANT PROTECTION LIMITED**

(a subsidiary of IMPERIAL CHEMICAL INDUSTRIES)

at its Research and Development Station

**at JEALOTT'S HILL, near BRACKNELL, BERKSHIRE**

for work on biologically active chemicals for use in crop protection. Applicants should possess good honours degrees in chemistry and post-graduate experience either at a university or in industry. They should not exceed 30 years of age and should write in the first instance, giving brief particulars only, to the Staff Officer, Plant Protection Limited, Fernhurst, near Haslemere, Surrey.

**CHELSEA COLLEGE OF SCIENCE AND TECHNOLOGY**

MANRESA ROAD, LONDON, S.W.3

DEPARTMENT OF CHEMISTRY

Applications are invited for the post of Lecturer or Assistant Lecturer in Inorganic Chemistry. Salary scales: Lecturer, £1,370 by £35 to £1,550; Assistant Lecturer, £700 by £27 10s. to £1,150; plus additions for training (£30 to £120); graduate status (£90); good Honours Degree (£75); London allowance of £38 or £51, according to age. The grading of the post will depend upon qualifications and experience.

Further particulars may be obtained from the Clerk to the Governors, by whom applications should be received not later than February 3, 1961.

**IMPERIAL COLLEGE OF SCIENCE AND TECHNOLOGY**

EXPERIMENTAL OFFICERS FOR PLASMA JET RESEARCH

Applications are invited from graduates in physics or chemistry interested in research in the field of high temperature gas dynamics. A plasma jet wind tunnel, capable of generating gas streams at stagnation temperatures up to 10,000 K, is under construction. Two Experimental Officers are required: commencing salary £850 per annum in scale £850 by £30 to £940 by £40 to £1,100. The appointments are for two years in the first instance and are superannuable.

Applications to Head of Aeronautics Department, Imperial College, London, S.W.7.

**LEIGH ELECTRONIC DEVELOPMENTS LIMITED**

HAVANT, HANTS

## LABORATORY TECHNICIAN

A Laboratory Technician is required with some experience of high vacuum work and some ability in glass blowing. O.N.C. qualifications will be advantageous. The successful candidate will be expected to take part in the development of prototype vacuum electronic devices.

A good salary will be paid, and in certain cases assistance towards rented housing can be given.

Applications to Regional Personnel Manager, Leigh Electronic Developments Limited, New Lane, Havant, Hants, quoting ref.: LED/23.

**PARKE, DAVIS & COMPANY**

require a LABORATORY TECHNICIAN for their PHARMACOLOGICAL RESEARCH LABORATORIES, preferably with some experience of general laboratory workshop practice, and building of electronic apparatus from specifications. Training will be given in the specific requirements on the job, with opportunities for further study.

Applicants should be 18+ years of age, preferably with a G.C.E. "A" level in Physics.

Terms of employment are attractive. They include a five-day, 37½-hour week, generous salary scale, and contributory life assurance plan. Staff restaurant.

Please apply to:
Personnel Manager,
Parke, Davis & Company,
Staines Road,
Hounslow, Middlesex.

BIRDS EYE
QUICK-FROZEN FOODS

BIRDS EYE FOODS LIMITED

requires a

## FOOD SCIENTIST

at its Head Office to undertake responsible work in the Quality Control Department concerned with the problems of the handling and distribution of quick-frozen foods. The successful applicant will be of good education, preferably to degree standard, with at least three years' industrial experience and already earning a four-figure salary. This is not a laboratory position and will appeal to those of good technical background who seek to broaden their experience in a new and exciting field.

Applications, giving details of qualifications, experience, and present salary, should be addressed to the Personnel Officer, Birds Eye Foods Ltd., Hesketh House, Portman Square, London, W.1.

SHELL

**" Shell " Research Limited**

require a

**Senior Technician**

for the

**Chemistry Division**

**at their Tunstall Laboratory, near Sittingbourne, Kent.**

The work of the Chemistry Division is extremely diverse and includes the formulation of chemicals for biological tests, the design and operation of inhalation chambers, and the development of micro-analytical techniques for the determination of biologically active compounds in tissues and body fluids. The Laboratory has an extensive programme and there are wide opportunities for development in all these fields.

Applications are invited from candidates with Higher National Certificate in Chemistry, or equivalent, and some 10 to 15 years' laboratory experience.

Salary will be based entirely on qualifications and experience. There is an attractive Pension Scheme together with other staff benefits.

***Please apply by letter, giving full details to :***

**Personnel Recruitment/T.C.,**
**" Shell " Research Limited,**
**St. Helen's Court,**
**London, E.C.3.**

**Ferranti** Semi-conductors

**NEW AND ADVANCED PROJECTS**

give rise to vacancies for

**RESEARCH AND DEVELOPMENT ENGINEERS**

in the

**SEMI-CONDUCTOR LABORATORIES**

These vacancies provide the opportunity of joining a first-class research and development team in modern well-equipped laboratories and of participating in independent work in this most important field of

**SOLID STATE PHYSICS**

Candidates should have a degree in physics or a higher national certificate in applied physics. A few, more senior vacancies, exist for candidates who already possess experience in semi-conductors or related fields.

These appointments will carry salaries fully commensurate with experience with excellent working conditions in a modern building on the Cheshire boundary. The Company has a Staff Pension Scheme and a Dependant's Insurance Scheme.

Application forms can be obtained from T. J. Lunt, Staff Manager, Ferranti Limited, Hollinwood, Lancs. Please quote reference AS.

THE UNITED STEEL COMPANIES LTD

MINERAL DRESSING AND EXTRACTION METALLURGY

**RESEARCH GRADUATE**

Graduate, preferably with several years experience, required for research project on the beneficiation of iron ores and other minerals used by the iron and steel industry. Research includes both fundamental and process studies on the sintering of iron ores. Applicants should have qualified in mineral dressing, physical chemistry, or chemical engineering. The commencing salary offered will be in the range £1,100 to £1,600 per annum depending on experience. The post is a long-term one and carries superannuation. The Company is prepared to assist with housing.

Applications should be addressed to :
The Assistant Director of Research,
The United Steel Companies Ltd.,
Swinden Laboratories,
Moorgate,
Rotherham.

**PRODUCTS APPLICATION**

*As a result of continuing expansion the following new staff are required :*

**PHYSICIST:** good honours degree, postgraduate, academic or industrial training in laboratory techniques, preferably concerned with optics and lighting, to supervise the building and calibration of an artificial sky and to carry out model experiments.

**EXPERIMENTAL ASSISTANT:** Higher National Certificate, to undertake the measurements and recording for the physicist.

**TECHNICAL OFFICER:** qualification in physics, electrical engineering or architecture, membership of the Illuminating Engineering Society, to be responsible for setting up and running a daylight service for the building industry. Duties will include the preparation of publications and lecturing

**CHEMIST:** degree or qualification in organic chemistry, research experience in paints adhesives or mastics, to undertake systematic study and evaluation of organic materials used with building glasses.

**Apply to the Personnel Officer (Graduate Recruitment),**

**PILKINGTON BROTHERS LIMITED**

***Glass Manufacturers***

**St. Helens, Lancashire.**

## VICTORIA COLLEGE

(UNIVERSITY OF BRITISH COLUMBIA CANADA)

Applications are invited for the following posts: Instructor in Mathematics; Instructor in French. Salary: $4,500 to $6,000 (depending on qualifications). Duties to commence September, 1961, but salary will be paid from July 1, 1961.

Applications, in duplicate, should be addressed to the Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1. A third copy should be sent by air mail to the Vice-Principal, Victoria College, Victoria, B.C., Canada. Candidates should ask three referees to write in support of their applications direct to the Secretary, Association of Universities. Applications close on February 11, 1961.

## UNIVERSITY OF DURHAM

Applications are invited for the newly established Chair of Inorganic Chemistry tenable in the Newcastle Division of the University. The successful candidate will be required to take up duty on August 1, 1961, or such other date as may be arranged. Salary in accordance with the Professorial scale (£2,600 to £3,000 a year) with family allowance and membership of F.S.S.U.

Further particulars may be obtained from the undersigned with whom applications (twelve copies) must be lodged not later than February 25, 1961. Candidates outside the British Isles may submit one copy only).

REGISTRAR.
University Office,
46 North Bailey,
Durham.

## UNIVERSITY OF LEEDS

DEPARTMENT OF MATHEMATICS

Applications are invited for appointment as Professor of Mathematics (either Pure or Applied) at a salary not less than £2,700 a year. The Chair is intended for a mathematician having research interests in one or more branches of mathematics related in a general or in a particular way to some field of technology.

Applications (sixteen copies), stating date of birth, qualifications and experience, together with the names of three referees, should reach the Registrar, the University, Leeds, 2 (from whom further particulars may be obtained) not later than February 14, 1961. Applicants from overseas may apply in the first instance by cable, naming three referees, preferably in the United Kingdom.

## NEW ZEALAND
### AGRICULTURE DEPARTMENT

Applications are invited for the undermentioned vacancy: Vacancy No. 3204: Scientific Officer, Agriculture Department, Taieri. Duties: To apply existing knowledge to improvement of eradication methods for rabbits and wallabies. To devise new methods of eradication, if necessary. A house will be provided at reasonable rental. Qualifications desired: Degree in science or agricultural science with zoology as major subject or other professional qualification where applicant has suitable biological training to equip him for work on eradication of noxious animals. Salary will be on the scientific officer scale up to £1,700 per annum dependent on qualifications and experience —further promotion beyond this point would be on scientific merit. Passages: Steamer fares of up to £165 each for the appointee and his wife, and pro rata for dependent children will be paid. Incidental expenses: Up to £35 for a single person and £100 for a married man can be claimed to cover the cost of taking personal effects to New Zealand.

Inquiries, quoting reference number B11/2/30, should be addressed to the High Commissioner for New Zealand, 415 Strand, London, W.C.2, who will furnish further details and application forms. Completed applications to be lodged with his office not later than February 15, 1961.

## POTATO MARKETING BOARD

Senior Scientific Officer to act as Secretary of a proposed Research and Development Committee which will be concerned with problems relating to the growing, harvesting, handling and marketing of potatoes. The successful applicant will be required to keep in touch with the chemical and biological aspects of the more important research work on potatoes at home and abroad, to follow up investigations that may be supported by the Board and to advise on the practical applications of new developments. Qualifications: Good honours degree in one of the following: agriculture, chemistry or biochemistry, with at least two years' research experience. Salary in the range £1,350 to £1,700 according to qualifications. Contributory pension scheme.

Application form from Establishment Officer, 50 Hans Crescent, Knightsbridge, London, S.W.1.

## UNIVERSITY OF GLASGOW
### RESEARCH FELLOWSHIP IN MATHEMATICS

Applications are invited for a Research Fellowship in Mathematics. Salary scale: £800 to £950 per annum. Initial salary according to experience and qualifications. F.S.S.U. and family allowance benefits.

Applications (three copies), should be lodged, not later than February 28, 1961, with the undersigned, from whom further particulars may be obtained.

ROBT. T. HUTCHESON,
Secretary of University Court.

## DEPARTMENT OF GEOPHYSICS
### UNIVERSITY OF WESTERN ONTARIO, LONDON, CANADA

Applications are invited for the position of Lecturer or Assistant Professor. Applicants should possess a Ph.D. or equivalent. Inquiries are also invited from persons wanting to carry out graduate research leading to a higher degree. Facilities are available for research in Terrestrial Heat Flow, Seismology, High Pressure Phenomena, Rock Magnetism, Nuclear Geology, Gravitation, Exploration Geophysics.

Lists will be closed on March 15, 1961, or when the positions are filled, whichever is the earlier. Inquiries should be addressed to the Head of the Department.

## MANCHESTER COLLEGE OF SCIENCE AND TECHNOLOGY
### SACKVILLE STREET, MANCHESTER, 1

A Senior Technician or a Chief Technician required in the Chemistry Department to join a chemistry research group and specifically to control and operate a High Resolution Nuclear Magnetic Resonance Spectrometer. Previous experience in this technique is not essential, but candidates should have a good knowledge of electronics or applied physics, and be interested in the further development of the technique for use in chemical research. Salary: Senior Technician, £700 to £765 per annum (with additions for approved qualifications). Chief Technician £825 to £925 per annum. 40 hour week. Superannuation scheme.

Applications, with full details, quoting reference No. C 6 to the Bursar. Closing date: February 14, 1961.

## UNIVERSITY OF READING

Applications are invited from persons of Ph.D. standard for I.C.I. Research Fellowships in Chemistry, Physiological Chemistry, Agricultural Chemistry, Agricultural Botany, Horticulture, Microbiology, Geology, Physics or related subjects to which some appointments may be made during the current academic year. The appointments will normally date from October 1, 1961. Salary, depending on qualifications and experience, within the range £700 to £1,000 per annum, with F.S.S.U. benefits and family allowances.

Applications (eight copies), with a list of publications and names of two referees, should be sent, not later than March 6, 1961, to the Registrar (Room 22, O.R.B.), The University, Reading, from whom further particulars may be obtained.

## WILMOT BREEDEN FELLOWSHIP

Applications are invited for a Fellowship, to be held in association with the University of Birmingham. The value of the Fellowship, which is for a two-year term, is £1,000 per annum.

A candidate for the Fellowship should normally have had two or three years' research or industrial experience. He should have an honours degree or equivalent qualification and be acceptable to the University of Birmingham as a research fellow.

The Wilmot Breeden Fellow would engage in an enterprise of such a character as to require the facilities both of the University and the Company, his time being spent at both. His enterprise may have the character of Scientific Research, Design, Development, a combination of some or all of these, or in some other way to be appropriate to the activities of Wilmot Breeden. The Company is especially concerned with Mechanisms, Electro-chemistry, Metal Finishing, Metallurgy, Metal Formation, Hydraulics, Electronics.

Full details may be obtained on application to the Secretary, Wilmot Breeden Fellowship Committee, Amington Road, Birmingham 25.

Final applications must be received by the Secretary before May 1, 1961.

## UNIVERSITY OF ABERDEEN

Applications are invited for an I.C.I. Research Fellowship in Biochemistry, Chemistry, Engineering, Pharmacology, or Physics or related subjects. Appointment from October 1, 1961, or earlier. Salary on scale £800 to £1,100 per annum, with placing according to qualifications and experience. F.S.S.U. and child allowance.

Conditions of appointment and forms of application should be obtained from the Secretary, The University, Aberdeen, with whom applications (10 copies) should be lodged by February 25, 1961. Applicants outside the British Isles may submit one copy of application.

## DURHAM COLLEGES
### IN THE UNIVERSITY OF DURHAM

Applications are invited for the post of Lecturer in Chemistry from October 1, 1961. The Lecturer will be expected to assist in the teaching of Inorganic Chemistry, and it is hoped that he will be interested in some aspects of organometallic chemistry or related topics.

Applications (three copies), together with the names of three referees, should be sent not later than February 4, 1961, to the Secretary, 38 North Bailey, Durham, from whom further particulars may be obtained.

## UNIVERSITY OF READING
### RESEARCH FELLOWSHIPS

Applications are invited for two Research Fellowships for independent research, value £700 per annum.

Further particulars may be obtained from the Registrar (Room 22, O.R.B.), the University, Reading, to whom applications should be sent by March 6, 1961.

ROYAL VETERINARY COLLEGE, LABORATORY Technician required as personal assistant to Reader in Biochemistry. Salary scale £490 to £675 per annum plus London weighting. Qualification allowance payable additionally in certain circumstances. Superannuation scheme.—Applications, with full particulars of age and experience, to Assistant Secretary, Royal Veterinary College, Royal College Street, London, N.W.1.

## NEW ZEALAND DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH
### VACANCY 3157. VACANCIES FOR CHEMICAL ENGINEERS

The Dominion Laboratory of the Department of Scientific and Industrial Research, New Zealand, has two vacancies for Chemical Engineers. The qualifications desired are a degree in chemical engineering and/or Corporate Membership of the Institute of Chemical Engineers. Postgraduate experience is required for one of the positions but the other is suitable for a recently qualified graduate. The current work of the Chemical Engineering Section includes; the utilization of timber by-products; the utilization of geothermal resources, fuel technology, development of mineral resources, curing of tobacco and hops. Independent research will also be encouraged. The salary offered is up to £1,800 a year, according to qualifications and experience. Subsequent promotion is on scientific merit and an outstanding officer can advance to £2,150 a year. Passages: Steamer fares of up to £165 each for the appointee and his wife, and pro rata for dependent children will be paid. Incidental expenses: Up to £35 for a single person and £100 for a married man can be claimed to cover the cost of taking personal effects to New Zealand.

Inquiries quoting reference number B11/21/36, should be addressed to the High Commissioner for New Zealand, 415 Strand, London, W.C.2, who will furnish further details and application forms. Completed applications to be lodged with his office not later than February 28, 1961.

## PHYSICIST FOR TEXTILE RESEARCH

An interesting vacancy has arisen for a young physicist with a knowledge of electronics and classical physics for work in the Lace Research Association. A man or woman with a good degree and an original mind will find the wide variety of the work stimulating and rewarding. Good working conditions and F.S.S.U. pension. Salary according to qualifications either as: Research Officer, £700 to £900 per annum or Senior Research Officer, £1,000 to £1,200 per annum.

Apply in confidence to Director of Research, Lace Research Association, Glaisdale Drive West, Bilborough, Nottingham.

## UNIVERSITY OF GLASGOW
### ASSISTANTSHIPS IN MATHEMATICS AND STATISTICS

Applications are invited for two Assistantships, one in Mathematics and one in Statistics. Salary scale: £800 to £950 per annum. F.S.S.U. and family allowance benefits.

Applications (three copies) should be lodged, not later than February 28, 1961, with the undersigned, from whom further particulars may be obtained.

ROBT. T. HUTCHESON,
Secretary of University Court.

AGRICULTURAL RESEARCH COUNCIL require a graduate, or equivalent, with good general grounding in analytical chemistry, for their Radiobiological Laboratory, Letcombe Regis, Wantage, Berks. Training given in low-level radiochemistry. Salary in scale: Assistant Experimental Officer, £625 (age 22) to £983; or Experimental Officer, £1,057 to £1,336, according to age, qualifications and experience. Contributory superannuation scheme.—Applications, with names of two referees, to Secretary of the Laboratory within 14 days.

COMMONWEALTH BUREAU OF PASTURES and Field Crops, Hurley, Berkshire, requires Scientific Assistant (abstractor) with degree in agriculture or natural science, and a knowledge of languages. Salary in scale £690 to £1,750. Age, qualifications and experience considered when fixing starting salary. Superannuation.—For further details and application form, apply to Director. Applications to be received by February 7.

INSTITUTE OF CANCER RESEARCH: Royal Cancer Hospital, Senior Technician required in Physics Department, Sutton, Surrey, to take part in investigations of low-level radioactivity. Experience in the development of modern equipment for the measurement of radioactivity is desirable. Appointment within range £700 to £850 according to qualifications. A suitably qualified candidate will be considered for appointment on M.R.C. Technical Officers' scales.—Apply with names of two referees to the Secretary, 33 Sumner Place, London, S.W.7, quoting ref. 301/B/46.

## CIVIL ENGINEERS FOR DEPARTMENT OF MAIN ROADS
NEW SOUTH WALES, AUSTRALIA

Applications are invited from graduates (or undergraduates in their final year) in Civil Engineering of a recognized British or Irish university for appointment to the staff of the Department of Main Roads, New South Wales, the State Road Authority for construction of roads and bridges. On appointment applicants may be engaged at the Department's Head Office, Sydney, on the design of reinforced concrete and steel bridges, or on main road constructions and maintenance either in the Metropolitan Area or the country. Commencing salary according to qualifications and experience will be within the range £A.1,325 to £A.1,650 per annum, with annual progression, subject to technical competence, to £A.2,400 per annum. Appointees will be eligible to contribute to the State Superannuation Fund after six months. Appointee's full fare from England to Australia will be met by the Department, subject to a three years' service guarantee bond being completed. Appointment will be subject to passing a medical examination, and preference will be given to applicants not more than 30 years of age.

Applications should be made on forms obtainable from the Agent-General for New South Wales, 56 Strand, London, W.C.2. Please quote No. 44/31 when writing.

## QUEEN MARY COLLEGE
(UNIVERSITY OF LONDON)

Applications are invited for the post of Assistant Lecturer or Lecturer in Organic Chemistry, tenable from October 1, 1961. Status and initial salary according to qualifications and experience. Salary scale: for Assistant Lecturer, £800 by £50 to £950, for Lecturer, £1,050 by £50 to £1,400 by £75 to £1,550 (efficiency bar) by £75 to £1,850. The appointment also carries a London allowance of £60, F.S.S.U. participation and family allowance of £50 for each child.

Application forms, obtainable from the Registrar, Queen Mary College, Mile End Road, E.1, to be returned by January 31.

## UNIVERSITY OF GLASGOW
I.C.I. RESEARCH FELLOWSHIPS

Applications are invited for I.C.I. Research Fellowships in Biochemistry, Chemistry, Engineering, Pharmacology, or Physics to which some appointments may be made during the current academic year. The appointments will date from October 1, 1961. The Fellows will hold the status of Lecturers in the University. The salary will depend upon qualifications and experience, but will be within the range £700 to £1,100 per annum, together with F.S.S.U. benefits and family allowances.

Applications (eight copies), with a list of publications and names of two referees, should be sent not later than February 28, 1961, to the undersigned, from whom further particulars may be obtained.

ROBT. T. HUTCHESON,
Secretary of University Court.

SENIOR LABORATORY TECHNICIAN FOR the Department of Chemistry. A vacancy occurs for a person possessing a background of experience that will fit him particularly for special responsibilities in the Departmental Store. Salary scales: With recognized qualifications, e.g., Final City and Guilds Certificate in Laboratory Technicians work £675 by four annual increments to £795 per annum, or without recognized qualifications £580 by three increments to £675.—Application should be made to the Chief Technician, Department of Chemistry, Chelsea College of Science and Technology, Manresa Road, S.W.3.

FIELDSMAN, EXPERIENCED PERSON required before April 1 who will be responsible for the placing and supervision of the growing and harvesting of all our crops of Aberystwyth seeds, and advice to Representatives on leys, etc. A house is available. Pension Fund.—Please write in confidence to Managing Director, stating age, experience and salary required to: W. Sinclair and Son Limited, 35 Market Place, Boston, Lincolnshire.

SHORTHAND TYPIST (FEMALE) OR typist accustomed to use of dictaphone and to working from manuscript, required for technical reports, papers and correspondence.—Apply, stating age, experience and salary required, to the Administrative Officer, Wellcome Veterinary Research Station, Frant, Near Tunbridge Wells.

## NORTHAMPTON COLLEGE OF ADVANCED TECHNOLOGY
ST. JOHN STREET, LONDON, E.C.1
HEAD OF CHEMISTRY DEPARTMENT

The Governing Body invites applications for the appointment of Head of the Department of Applied Chemistry as a successor to Dr. J. Leicester, who has been appointed Principal of the Northern Polytechnic, London. Candidates should have good academic qualifications with teaching and/or industrial experience. The Department of Applied Chemistry prepares students for Diplomas in Technology, for Higher National Certificates in Chemistry and for the final examination for Grad.R.I.C. A considerable amount of research is carried out and there are wide industrial contacts. Salary scale: Grade V under the current Burnham Technical Award, viz.: £2,100 per annum by increments of £50 to £2,250 per annum (plus London allowance £38 to £51 per annum).

Further particulars and application form from the Secretary of the College. Applications must be submitted not later than February 17, 1961.

J. S. TAIT, Ph.D., B.Sc.(Eng.), A.R.T.C., M.I.E.E., M.I.Mech.E.,
Principal.

A SENIOR MICROBIOLOGIST IS REquired at Worthing to take charge of the Microbiological Laboratory associated with Antibiotic Production. Applicants should be qualified, and preferably have had previous experience of Microbiological Assay methods, sterility testing, and culture maintenance techniques.

Good salary, non-contributory pensions, and staff profit sharing schemes in operation.

Apply in writing, giving details of age, qualifications and experience, to Personnel Officer, Beecham Research Laboratories Ltd., Clarendon Road, Worthing, Sussex.

## CENTRAL ELECTRICITY GENERATING BOARD
NORTH-EASTERN AND YORKSHIRE REGION
PHYSICISTS

Physicists are required by the Research and Development Department at their laboratories in Leeds. The successful candidates will join a small team pursuing investigations concerned with electricity generation and transmission. They will carry out research on heat transfer to liquids with rotational flow on a laboratory rig, but will also be expected to help investigate other problems in the fields of heat transfer, electrical insulation, instrumentation and mechanics. Applicants should have a good honours degree, and for the more senior post at least two years' postgraduate research experience. The salary scale for this post will be in the range £1,105 to £1,720 per annum. For the other post experience is not essential, and the initial salary scale will be within the range £780 to £1,165 per annum.

Forms of application may be obtained from the Assistant Regional Secretary (Personnel), Central Electricity Generating Board, North-Eastern and Yorkshire Region, 1, Whitehall Road, Leeds 1, to whom they should be returned to arrive not later than February 18, 1961.

## UNIVERSITY COLLEGE OF NORTH WALES
BANGOR

Applications are invited for the post of Technician at the Marine Biology Station. Preference will be given to applicants with experience in workshop practice or in histological techniques. The salary scale is £490 by £20 to £550—efficiency bar—£600 by £25 to £675, the commencing salary being fixed according to qualifications and experience. There is a Pension Scheme.

Applications, giving details of experience, together with the names of two referees, should be sent to the Registrar, University College of North Wales, Bangor, as soon as possible.

HORTICULTURAL RESEARCH ASSISTANT required for practical development of new insecticides and fungicides on field scale, mainly on fruit. Degree in applied botany (plant pathology) or entomology essential, preferably with horticultural bias and postgraduate experience. Knowledge of fruit growing a distinct advantage. Salary according to age and experience.—Write, giving full details, to Personnel Officer, The Murphy Chemical Co. Ltd., Wheathampstead, St. Albans, Herts.

## UNIVERSITY OF DUBLIN
TRINITY COLLEGE
I.C.I. RESEARCH FELLOWSHIPS

Applications are invited for I.C.I. Research Fellowships in Biochemistry, Chemistry, Civil Engineering or Physics, to which some appointments may be made during the current academic year. The appointments will date from October 1, 1961 (or earlier in the case of selected candidates who may be available before that date). The salary will depend on qualifications and experience, but will be within the range £760 by £47 10s. to £1,045 per annum, with membership of a non-contributory Superannuation and Life Assurance Scheme, and with marriage and family allowances.

Applications (four copies), giving full details of career, and the names and addresses of three referees, should reach the Registrar, Trinity College, Dublin, from whom further particulars may be obtained, not later than February 12, 1961.

## QUEEN'S UNIVERSITY OF BELFAST

The Senate of the Queen's University of Belfast invites applications for two Lectureships in Engineering Mathematics from October 1, 1961. Salary range £1,050 to £1,850, plus contributory pension rights under the F.S.S.U. Initial placing on the salary scale will depend on qualifications and experience. Applications should be received by March 10, 1961.

Further particulars may be obtained from G. R. Cowie, M.A., LL.B., J.P., Secretary.

## MEDICAL RESEARCH COUNCIL OF IRELAND

Applications are invited from Pharmacologists, Biochemists, or Organic Chemists with biological experience. Applicants must be of Ph.D. standard, and the work will be in the field of chemotherapy. Remuneration £800 to £1,000, depending on qualifications and experience.

Applications, accompanied by the names of two referees, should be sent to the Secretary, Medical Research Council of Ireland, 50 Merrion Square, Dublin.

## UNIVERSITY OF CANTERBURY
CHRISTCHURCH, NEW ZEALAND
SENIOR TECHNICIAN—ZOOLOGY DEPARTMENT

Applications are invited for the above-mentioned post. Applicants should have training in histological techniques and the preparation of teaching material. The salary range for this position is £965 to £1,125 per annum; Commencing salary according to qualifications and experience.

Further particulars and information as to the method of application should be obtained from the Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1. Applications close on February 15, 1961.

PHYSICIST WITH ELECTRONIC AND/OR instrument experience, and preferably at least honours degree, required for fundamental and applied research in a growing organization concerned with building materials.—Write for form of application to Box No. 937, T. G. Scott and Son, Ltd., 1 Clement's Inn, London, W.C.2.

RESEARCH ASSISTANT WANTED APRIL 1 for work on amino-acid metabolism. Preferably graduate. Laboratory experience in chemistry or biochemistry essential.—Apply, in writing, to Dr. L. J. Woolf, Department of Regius Professor of Medicine, Radcliffe Infirmary, Oxford.

ASSISTANT EXPERIMENTAL OFFICER required by Research Institute, Pirbright, for work in Serology Section. Qualifications: Pass degree in zoology or bacteriology, experience in serology an advantage. Salary according to age in scale from £600 at age 22, rising to £945.—Applications to Secretary.

BEDFORD COLLEGE (UNIVERSITY OF London), Regent's Park, N.W.1. The Council invites applications from Honours graduates for the following: (a) Assistant Lectureship in Physics, preferably with postgraduate experience in nuclear physics. (b) Two Assistant Lectureships in Botany, preferably with postgraduate experience in (i) genetics, and (ii) mycology or microbiology. Vacant October 1, 1961: open to men and women. Salary scale £800 by £50 to £950, plus £60 per annum London allowance, with initial salary according to qualifications and experience. Closing date for applications February 28, 1961.

Full particulars from the Secretary.

## UNIVERSITY OF QUEENSLAND

SENIOR LECTURER OR LECTURER IN ELECTRICAL ENGINEERING

Applications are invited for the above-mentioned position. Applicants must hold an honours degree and for the Senior Lectureship a higher degree in electrical engineering with specialization in electronics. The duties will include lectures on advanced topics in the field of electronics and arrangement of the appropriate practical work. Participation in the research work of the Department is expected. The salary ranges are: Senior Lecturer, £A.2,520 by £A.70 to £A.2,870; Lecturer, £A.1,830 by £A.70 to £A.2,330. The successful applicant will enjoy the privileges of superannuation, study leave, travel grants and other benefits available to the academic staff.

Further particulars and application forms are available from the Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London W.C.1. Applications close, in Australia and London, on February 15, 1961.

## NATIONAL COLLEGE OF FOOD TECHNOLOGY

ST. GEORGE'S AVENUE, WEYBRIDGE, SURREY

Principal: J. D. Mounfield, M.Sc.Tech., Ph.D., F.R.I.C.

Applications are invited for the post of Assistant Lecturer in the College from graduates in chemistry, preferably from those with experience in the food industry. The duties will include the teaching of chemistry and food quality control. Salary scale: £790 by 15 at £27 10s. and one at £37 10s. to £1,240 per annum. Starting salary dependent on qualifications and experience.

Application forms (obtainable from the College) should be sent to the Principal as soon as possible.

## BRITISH TITAN PRODUCTS COMPANY LIMITED

RESEARCH STUDENTSHIP IN INORGANIC CHEMISTRY

Applications are invited for the above studentship, which will become vacant on October 1, 1961. Candidates will be expected to conduct independent research in some branch of inorganic chemistry. They should be normally resident in the U.K. and be British subjects. They should have completed the degree of Ph.D. The emolument will be £850 and the tenure usually three years. Applications should be submitted before March 6, 1961.

Further details can be obtained from Dr. F. B. Kipping or Dr. A. G. Sharpe at the University Chemical Laboratory, Lensfield Road, Cambridge.

## UNIVERSITY OF HULL

I.C.I. RESEARCH FELLOWSHIPS

Applications are invited for Imperial Chemical Industries Research Fellowships in Chemistry or Physics normally tenable for three years from October 1, 1961. Salary will depend on qualifications and experience, but will be within the range £800 to £1,100 per annum, together with F.S.S.U. benefits and family allowances.

Applications (five copies), with a list of publications and the names of two referees, should be sent not later than March 7, 1961, to the undersigned, from whom further particulars can be obtained.

W. D. CRAIG,
Registrar.

THE CARBORUNDUM COMPANY LIMITED has a vacancy for a Quality Control Statistician in its Technical Branch at Trafford Park, Manchester. The successful applicant will be required to work on problems of applying statistical quality control methods in the manufacture of the company's various product lines. A good science or mathematics degree is essential. The post offers good prospects with ample scope for advancement. Good working conditions, bonus scheme, and generous pension scheme.—All applications, which will be treated in strict confidence, should include details of age, qualifications and experience, and should be addressed to the Manager, Quality Control Department, Technical Branch, The Carborundum Company Ltd., Trafford Park, Manchester, 17.

YOUNG WOMAN SCIENCE GRADUATE, preferably in physiology or biology, required for interesting and responsible post in the Department of Applied Electrophysiology. Duties after training include supervising recording of electroencephalograms and interpretation of records. There are opportunities for human electrophysiological research. Salary according to age and experience.—Apply in writing to the Secretary to the Board of Governors, the National Hospital, Queen Square, W.C.1.

## ENGLISH ELECTRIC VALVE CO. LTD.

CHELMSFORD, ESSEX

**A PHYSICIST *or* MATHEMATICIAN**

is required for research on electron optical systems.

Applicants should possess a first or second class honours degree in physics or mathematics and be preferably within age range 22 to 30.

Salary will take into account age and any previous relevant experience.

Apply to Dept. G.P.S., English Electric House, Strand, London, W.C.2, quoting reference N.1595L.

## PARKE, DAVIS & COMPANY

A vacancy exists in the DEPARTMENT OF PHARMACOLOGICAL RESEARCH for a QUALIFIED PHARMACOLOGIST with RESEARCH EXPERIENCE.

The work will be concerned with the search for new pharmacodynamic agents. Those with Ph.D., M.Sc., B.Sc., or B.Pharm. degrees, or equivalent qualifications, are invited to apply for this post.

The terms of employment with the Company are attractive. They include a generous salary, pension and life assurance plan, and a five-day, 37½-hour week.

Please apply:
Personnel Manager,
Parke, Davis & Company,
Staines Road,
Hounslow, Middlesex.

## OLDCHURCH HOSPITAL ROMFORD, ESSEX

(709 Beds)

RADIOTHERAPY DEPARTMENT

Senior Technician or Technician required for the above Department. Duties include Physics Workshop, Isotope Laboratory, Radium and Mould Room work. Instrument or Physics Workshop experience essential. Salary £570 to £710 per annum; senior grade, £710 to £905 per annum would be applicable to suitably qualified person.

Applications, quoting Ref. 17/39, giving full details, including age and experience, together with names of two referees and/or copy of testimonials to the Group Secretary, Romford H.M.C., Oldchurch Road, Romford.

## QUEEN ELIZABETH COLLEGE

(UNIVERSITY OF LONDON)
CAMPDEN HILL ROAD, W.8

Applications are invited from candidates with responsible teaching and research experience for a Lectureship in the Physics Department, vacant in October, 1961. In view of the expansion of the Department preference will be given to applicants with sufficient standing to be appointed in the upper part of the scale for Lecturers.

Further particulars from the Secretary.

NATIONAL VEGETABLE RESEARCH Station, Wellesbourne, Warwick, requires Scientific Officer in Weeds Section to work on problems associated with the absorption, mobility and persistence of herbicides in soils. Qualifications: good honours degree in chemistry or botany, preferably with some postgraduate experience. Salary in scale £690 to £1,144. F.S.S.U.—Applications, with names and addresses of three referees, to Secretary by January 28, 1961.

## KENYA

GEOLOGIST

Qualifications: Candidates must have a first- or good second-class honours degree in geology. Aptitude in field mapping, economic geology and petrology desirable. Age limits: 21 to 27. Duties: Regional geological mapping, examination of mineral deposits, preparation of reports and maps for publications. Terms of appointment: On probation for permanent and pensionable establishment. Salary according to experience in the scale £981 to £1,863 (under review). Outfit allowance. Free family passages. Quarters at rental or hotel allowance. Generous leave. Taxation at local rates.

Apply to Director of Recruitment, Colonial Office, London, S.W.1, stating full name, age, qualifications and experience. Quote BCD.99/7/02/C1.

## NATIONAL INSTITUTE FOR RESEARCH IN DAIRYING

(UNIVERSITY OF READING)

Honours graduate in chemistry or biochemistry required in Radiobiochemistry Department for biochemical research involving the use of radioactive isotopes and in particular $C^{14}$ and tritium. The appointment will be made in the grade of Scientific Officer (£717 to £1,222) or of Senior Scientific Officer (£1,302 to £1,654) at a salary commensurate with experience and qualifications; F.S.S.U. Facilities exist to register for higher degree.

Applications, naming two referees, to the Secretary, N.I.R.D., Shinfield, Reading. Quote ref. 61/1.

UNIVERSITY OF LONDON: APPLICATIONS are invited for Imperial Chemical Industries Research Fellowships in Biochemistry, Chemistry, Chemotherapy, Engineering, Metallurgy, Pharmacology or Physics. The Fellowships will normally be tenable from October 1, 1961, for three years. Candidates should preferably have a Ph.D. degree or equivalent research experience. Stipends will be within the range of £900 to £1,100 per annum, with annual increments of £50 up to £1,100, the starting point within the range being dependent upon experience and qualifications. Family allowance and F.S.S.U.—Detailed regulations and application forms may be obtained from the Academic Registrar, University of London, Senate House, W.C.1. Applications must be received not later than April 15, 1961.

THE LABORATORY OF BACTERIOLOGY of Cornell University invites applications for Teaching and Research Assistantships. Applicants must be qualified to work for an advanced degree (M.S. or Ph.D.) in Bacteriology, although prior bacteriology training is not required. Stipends are usually in the range of $2,200 to $3,200 per annum. Applications for the academic year 1961-62 should be completed by April.—Further details and information may be obtained from Professor E. A. Delwiche, Laboratory of Bacteriology, Cornell University, Ithaca, New York, U.S.A.

THE BRITISH OXYGEN COMPANY LIMITED have a vacancy in the Information Section of their Scientific Division for a graduate in science or engineering. The work includes abstracting and literature searching and covers a wide range of subjects.—Applicants should write to the Administration Manager, The British Oxygen Company Ltd., Scientific Division, Deer Park Road, London, S.W.19.

## TRADE ANNOUNCEMENTS

SILICA CONES AND SOCKETS, VITREOsil silica tubing, polished silica discs and glazed sheet always in stock.—Custom built silica/quartz apparatus from Jencons. The Silica Centre, Mark Road, Hemel Hempstead, Hertfordshire. Boxmoor 4641.

UNWANTED MICROSCOPE — TURN IT into cash. We buy at top prices microscopes up to 50 years old, also barographs. Send or bring to the specialists. Wallace Heaton Ltd., 127 New Bond Street, London, W.1.

## LECTURES AND COURSES

UNIVERSITY COLLEGE LONDON (GOWER St., W.C.1). Inaugural Lecture by Dr. E. H. S. Burhop, Professor of Physics, entitled "The Techniques of High Energy Physics" will be given on Monday, January 23 at 5.30 p.m.—Admission free, without ticket.

## WOLVERHAMPTON AND STAFFORDSHIRE COLLEGE OF TECHNOLOGY

DEPARTMENT OF APPLIED SCIENCE

THE NEWER METALS

Eight lectures, on Thursday evenings, 7.0-9.0 p.m., commencing January 19, 1961, will deal with recent chemistry, extraction, properties, uses and future uses of the following elements:

Gallium, Indium and Thallium.
Dr. N. N. Greenwood (University of Nottingham).
The Actinide Elements.
Dr. G. R. Hall (Imperial College, London).
Titanium.
Dr. J. Lewis (University College, London).
Vanadium, Niobium and Tantalum.
Dr. G. W. A. Fowles (University of Southampton).
Palladium and Platinum.
Dr. R. G. Wilkins (University of Sheffield).
Germanium.
Mr. A. R. Powell, F.R.S. (Johnson, Matthey & Co., Ltd.).
Beryllium.
Mr. L. Grouzott (I.C.I. Metals Division, Birmingham).
Zirconium.
Dr. P. H. Morton (I.C.I. Metals Division, Birmingham).

Fee: £1 10s. 0d.

Application forms available from The Principal, Wolverhampton and Staffordshire College of Technology, Wulfruna Street, Wolverhampton.

## CITY OF LIVERPOOL EDUCATION COMMITTEE

COLLEGE OF TECHNOLOGY
BYROM STREET, LIVERPOOL 3

Post-Graduate Courses—Spring, 1961

The following courses have been arranged:

(a) Two-day Full-time Courses.

1. "Polarographic Techniques"—February 23 and 24, 1961.
2. "Industrial Thermodynamics"—March 23 and 24, 1961 (in collaboration with the Extra-mural Department of the University of Liverpool).
3. "Foams"—Industrial and Theoretical Aspects—April 27 and 28, 1961.
4. "Course for Teachers of Biology"—April 28 and 29, 1961.

(b) Two-weeks' Full-time Lecture and Practical Courses.

1. "Radiation Safety and Health Physics" (i) February 6 to 17, 1961; (ii) April 10 to 21, 1961.
2. "Radiobiology"—May 1 to 12, 1961.

Further details and application forms may be obtained from the Head of the Department of Chemistry and Biology.

THOMAS ALKER,
Town Clerk and Clerk to the Local Education Authority. (J 6584)

## IMPERIAL COLLEGE OF SCIENCE AND TECHNOLOGY

LONDON, S.W.7

A course of postgraduate lectures on Fire Hazard of Materials arranged by Dr. J. H. Burgoyne will be given in the Department of Chemical Engineering and Chemical Technology throughout the week commencing Monday, February 13, 1961.

Details from the Registrar.

## IMPERIAL COLLEGE

DEPARTMENT OF CHEMICAL ENGINEERING

Course of twelve lectures will be given by Dr. K. E. Weale and Dr. K. E. Bett on "Polymerization at High Pressures" and "The Design of High Pressure Laboratory Equipment." Two lectures will be given every Thursday afternoon, beginning at 2.30 p.m. on February 9, 1961.

Applications to the Registrar, Imperial College London, S.W.7.

## LONDON SCHOOL OF HYGIENE AND TROPICAL MEDICINE

ACADEMIC POSTGRADUATE DIPLOMA IN BACTERIOLOGY OF THE UNIVERSITY OF LONDON

The course for the Postgraduate Diploma in Bacteriology for the session 1961-62 will commence in October, 1961. This is a full-time day course extending over one academic year. Fee for the course £73 10s. (including the School registration fee of £3 3s.). The course may be taken by: (a) Graduates in Medicine, Science or Pharmacy of this or another approved university, whose previous training has, in the opinion of the University, fitted them to profit by the course. (b) Registered medical practitioners and other students, who, though not graduates, have obtained a qualification and undergone a previous training which, in the opinion of the University, has fitted them to profit by the course. Applications for admission to the Diploma course must be received not later than March 1, 1961.

Further information and application forms can be obtained from the Registrar, London School of Hygiene and Tropical Medicine, Keppel Street (Gower Street), London, W.C.1.

## ROYAL TECHNICAL COLLEGE

SALFORD

DEPARTMENT OF ELECTRICAL ENGINEERING

Head of Department: J. H. Calderwood, M.Eng., Ph.D., M.I.E.E., F.Inst.P.

A Course of six lectures on "Electrical Insulation" will be given on Tuesdays at 7 p.m., commencing on February 7, 1961. The fee for the course is £1 11s. 6d.

Further details may be obtained from the Head of the Electrical Engineering Department.

## GRANTS & SCHOLARSHIPS

THE PIG INDUSTRY DEVELOPMENT AUTHORITY

### SCHOLARSHIPS

The Pig Industry Development Authority offer postgraduate training scholarships to suitable students in Agriculture, Veterinary Medicine, Economics, Statistics, or other appropriate subjects who wish to receive training and undertake research in some aspect of the pig industry.

Annual values are: Veterinary Medicine, £750; other subjects, £500 to £750.

A few Senior Fellowships are also available.

Further details and application forms obtainable from the

Secretary, PIDA House,
Ridgmount Street, London, W.C.1.

Forms should be returned by March 15, 1961.

## SCHOLARSHIPS ABROAD, 1961-62

Applications are invited from British students for scholarships offered by Austria, Belgium, Brazil, Denmark, Finland, France, Germany, Iceland, Indonesia, Iran, Italy, Japan, The Netherlands, Norway, Poland, Portugal, Spain, Sweden, Switzerland and Yugoslavia. The awards are mainly for university graduates and undergraduates, and are tenable for periods varying from a few weeks to twelve months during the academic year 1961-62.

Full particulars and application forms, for which a stamped (3d.) self-addressed adhesive label should be sent, are obtainable from The British Council, 65 Davies Street, London, W.1, or from any British Council office in the United Kingdom.

## UNIVERSITY OF OXFORD

METALLURGICAL RESEARCH

Several Research Bursaries are offered for work in the Department of Metallurgy on various problems in Physical Metallurgy. The Bursars are expected to read for the Oxford D.Phil. degree, and the work provides valuable training and experience. The Bursaries are of the value equivalent to those of D.S.I.R. Research Studentships (at present £420 per annum tax free, plus approved fees).

Candidates should have a first- or good second-class honours degree in metallurgy, physics or chemistry and should apply as soon as possible to Professor W. Hume-Rothery, Department of Metallurgy, Parks Road, Oxford, from whom full details can be obtained. Applications can be received from those graduating in the Summer of 1961, and those appointed will be expected to begin work on October 1.

## CHURCHILL COLLEGE

CAMBRIDGE

RESEARCH AND POSTGRADUATE STUDENTSHIPS

Churchill College offers the following Studentships, to commence in October, 1961, for qualified male candidates from the United Kingdom and overseas:

(a) One Research Studentship for men who intend to proceed to the degree of Ph.D. of the University of Cambridge.

(b) One Gulbenkian Studentship for men who intend to proceed to the degree of Ph.D. of the University of Cambridge and who are graduates of universities other than those in the United Kingdom; graduates of such universities, who have subsequently taken a degree in the United Kingdom, are also eligible.

(c) One Postgraduate Studentship for men who intend to pursue approved courses leading to Certificates of Postgraduate Study or Certificates of Advanced Study or certain Diplomas* of the University of Cambridge.

The elections will take place in May, 1961. The Research Studentships will normally be tenable for three years and the Postgraduate Studentships for one year. The value will be determined by the College Council after considering the Student's income from other studentships or grants, and will not exceed £465 a year in addition to the payment by the College of approved College and University fees.

Further particulars can be obtained from the Tutor for Advanced Students, Churchill College, Cambridge. Applications for Studentships must be received before April 1, 1961.

*The Diploma in Mathematical Statistics. The Diploma in Numerical Analysis and Automatic Computing. The Diploma in Economics.

## UNIVERSITY OF READING

RESEARCH SCHOLARSHIPS

Applications are invited for Research Scholarships and one Huntley and Palmers Agricultural Research Scholarship from persons who hold a first degree or who will have completed a first degree course by July, 1961. The Scholarships are tenable for a maximum period of three years from October 1, 1961, subject to annual renewal, and will be of the value of £315 per annum, together with payment of the Composition Fee.

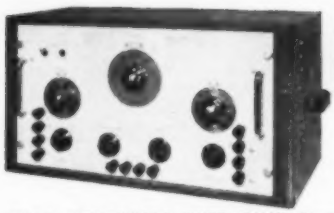
Further particulars may be obtained from the Registrar (Room 22, O.R.B.), the University, Reading by whom applications must be received not later than March 17, 1961.

## FOR SALE AND WANTED

ALMOST ANY BACKNUMBERS AND volumes of *Nature* wanted. Also learned and scientific journals, transactions of most kinds. Further: *Notes and Queries*, the *Annual Register*, *Quarterly Review*, *Palmer's* and/or the *Official Index* to the *Times*, *British National Bibliography*, *English Catalogue of Books*, *Journal Royal Philosophical Society*, *Royal Statistical Society*, etc.—H. Pordes, 138 New Cavendish Street, London, W.1. MUSeum 5250.

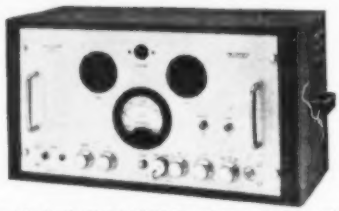
HARRINGTON
BROTHERS LIMITED
PERIODIC ACID
SODIUM & POTASSIUM
PERIODATES
GENERAL LABORATORY & RESEARCH REAGENTS
OLIVERS YARD, CITY ROAD, LONDON, E.C.1

NYLON • P.T.F.E.
ROD, BAR, SHEET, TUBE, STRIP, WIRE
*No Quantity too small • List on application*
BRASS · COPPER · DURAL · ALUMINIUM · BRONZE
H. ROLLET & CO., LTD.
LONDON, BIRMINGHAM, LEEDS, LIVERPOOL, MANCHESTER

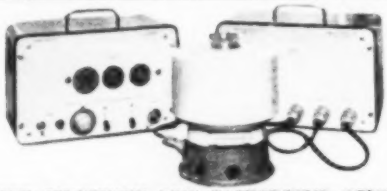


# PANAX Nucleonic Instruments

**PULSE GENERATOR TYPE G100H** Single or double pulses on two channels. 0-50v. Pos. or Neg. Delay 0-1milli Sec. Pulse widths 1micro Sec-1milli Sec. Rise time 0.2micro Sec. 10 separate pulse outputs.



**FAST SCALER TYPE 100C** Complete counting equipment. Hard valve plug-in decade units. Stabilized EHT supply 0-2Kv. Pre-amplifier and discriminator.



**HIGH SENSITIVITY LOW BACKGROUND GEIGER COUNTING EQUIPMENT** An anticoincidence assembly comprising lead castle type LC-5 which houses a Mullard guard counter assembly type MX157, Scaler type SA.102 and anticoincidence unit type AU460. Typical backgrounds less than 1.5 c.p.m.

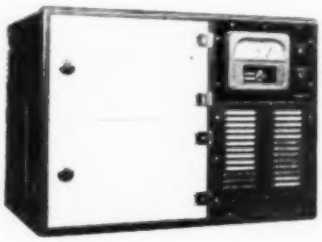
**AUTO-SCALER TYPE AC/300/6** Complete automatic counting equipment with preset count and preset time facilities. Stabilized EHT supply 0-2,000v. Accurate metered discriminator 1-50v Pos. and 0.1-5v Neg.

**GENERAL PURPOSE RADIATION MONITOR TYPE 5054** Ratemeter ranges 0-400, 0-2,000, 0-10,000 and 0-40,000 cpm. Int. time constans 1-5-25 Sec. Discriminator range 0.1-5v neg. 1-50v pos. Stabilized EHT variable 0-2Kv. Various probes available: Beta, Gamma, large area Alpha.

## PHYSICAL SOCIETY EXHIBITION STAND No. 85

**FOR HIGH EFFICIENCY COUNTING OF LOW ENERGY BETA PARTICLES**

**SCINTILLATION COUNTER TYPE SC/LP** For the measurement of Carbon 14 and Tritium using liquid phosphors. Incorporates a light-tight door, automatic shutter and cooling coils. In addition anthracene crystals can be used for the counting of low energy beta emitting solids, also sodium iodide crystals for gamma counting and zinc sulphide screens for Alpha counting.



**REFRIGERATOR TYPE RU1660** Designed for use with counter type SC-LP when high efficiency counting of Tritium is required under plateau conditions. The temperature range extends below −15°C and is accurately controlled. A pump circulates the coolant round the counter cooling coils.

**WELL COUNTER TYPE USC/B** The USC well counting assembly shown mounted in the popular Universal Lead Castle Type LC/3.

**DIRECTIONAL SCINTILLATION COUNTER TYPE USC/D** with amplifier type 4250, adjustable bracket and removable collimator.

**UNIVERSAL SCINTILLATION COUNTERS** Shown above in some of the variations possible with these counters. All the units use the same basic photomultiplier assembly together with various crystal mounts which cover the widest possible range of applications.

**For further details of these and other instruments and accessories send for our latest catalogue and price list.**

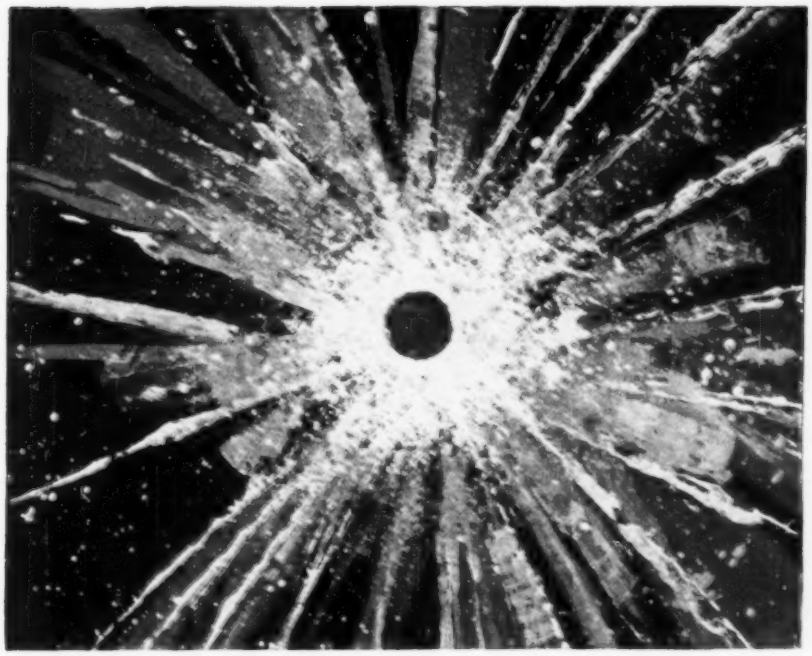
## PANAX EQUIPMENT LTD

**HOLMETHORPE INDUSTRIAL ESTATE**

**REDHILL, SURREY**

**Telephone: Redhill 3511 (2 lines)**

**EXPORT DIVISION, EMEFCO HOUSE, REIGATE**



Plessey

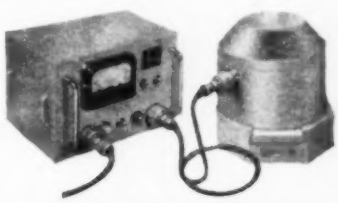
# Radiation Monitors and Detectors

Growing acceptance of the radiation monitor and detector devices developed by Plessey Nucleonics Limited establishes their overall superiority. Indeed, the PNL instruments illustrated here offer substantial improvements of robustness and convenience of application over the type available hitherto.

Selective Gamma Monitor type 1080 — Publication No. PNL 111

## PNL programmes for nucleonic development

PNL is engaged in the design and manufacture of standard and specialised nuclear instrumentation — burst fuel element detectors for reactors, flux scanning equipment, radiation detectors of all types, process control instrumentation, health and defence instruments. The parallel production by PNL of so much that is complementary in nuclear instrumentation has established within the Company a unique bank of scientific skills and techniques, which is now offered for the development of new projects. The Company's liaison engineers are freely available to assist with problems in their field.



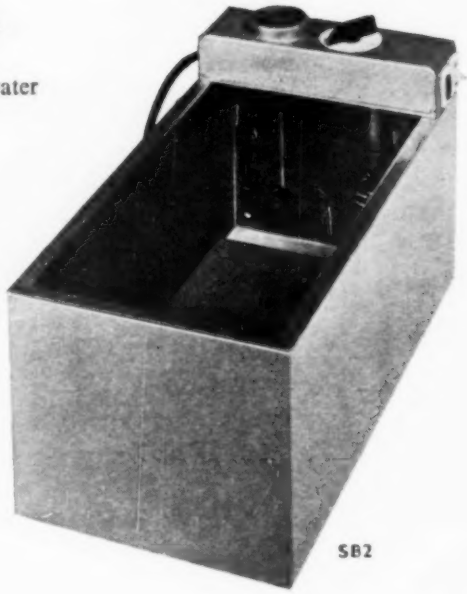
General Purpose Contamination Monitor type 1065— Publication No. PNL 112

**PLESSEY NUCLEONICS LIMITED** · WEEDON ROAD · NORTHAMPTON
Telephone: Northampton 4966 · One of The Plessey Group of Companies
Overseas Sales Organisation: Plessey International Limited · Ilford · Essex · Telephone Ilford 3040

PLN.M2

# the standard laboratory bath

Stainless steel tank: Propeller stirring.
Dial marked in degrees Centigrade.
Available with pump for circulating water through other apparatus.
Wide range of test-tube racks, lids, cooling and constant level devices.
Unconditionally guaranteed for one year. Forty-eight hour repair service, and loan units available by return of post.



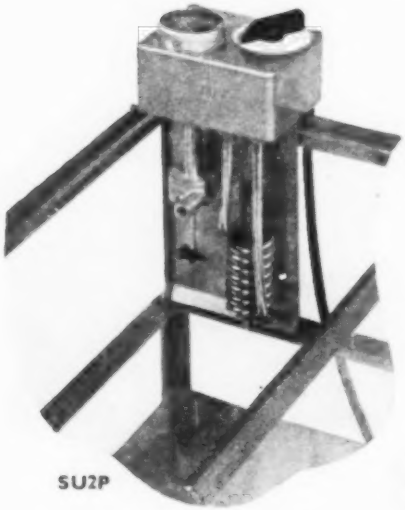
SB2

**Standard Models**

| **Range 10° to 100° C** | **±0·25° C** |
|---|---|
| SB1 (9″×8″×6″) ... | **£27 5 0** |
| SB2 (15″×8″×6″) ... | **£28 10 0** |
| SB3 (21″×12″×11″) | **£32 0 0** |
| SB4 (15″×12″×9″) | **£31 0 0** |

(working space in brackets)

# thermostatic control unit



SU2P

**MODELS SU2 and SU2P**

This unit enables any vessel to be used as a thermostatically controlled bath. If fitted with a pump (as illustrated) it is particularly useful for circulating water at a controlled temperature through other apparatus. The heater, thermostat and stirrer are exactly as fitted to our standard baths.

Model SU2 (without pump) **£19 10 0**
Model SU2P (with pump) **£22 10 0**

## Grant Instruments

**(Cambridge) Ltd.**

**Barrington, Cambridge Telephone: Harston 528**


Printed in Great Britain by Fisher, Knight & Co., Ltd., The Gainsborough Press, St. Albans, and published by Macmillan & Co., Limited, at St. Martin's Street, London, W.C.2, and St. Martin's Press, Inc., 175 Fifth Avenue, New York 10, N.Y., U.S.A.—Saturday, January 14, 1961.